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# CCD photometry of variable stars in the Magellanic Clouds – VI. The eclipsing binary HV 982 in the LMC

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**ABSTRACT**
Using improved techniques, high-quality CCD *uvbyVI* photometry has been obtained for the eclipsing binary HV 982 in the Large Magellanic Cloud (LMC). *IUE* ultraviolet spectrophotometry was also obtained. These data have been analyzed using the Wilson-Devinney synthetic light-curve code and Kurucz low-metallicity model atmospheres as well as the EBOP code. The system is detached and the orbit is eccentric. Apsidal motion is detected with apsidal period $205 \pm 7$ yr. The effective temperatures of the components are found via flux fitting to be $T_{\mathrm{eff},1} = 28\,000 \pm 5\,000$ K and $T_{\mathrm{eff},2} = 27\,200 \pm 5\,000$ K. The large errors result from uncertainties over the appropriate interstellar extinction correction. The system plausibly comprises two $\sim 8\,\mathrm{M}_{\odot}$ stars of radius 6–7 $\mathrm{R}_{\odot}$ separated by $\sim 30\,\mathrm{R}_{\odot}$.

For pedagogical and historical interest, the near simultaneity of the eclipse minima at different wavelengths is used to constrain the constancy of the speed of light with wavelength and the mass of the photon, yielding $m_{\gamma} < 10^{-41}$ kg. Because of the great distance to HV 982, this limit is some $10^2$ times smaller than previously achieved with eclipse timings, but it is nevertheless 10 orders of magnitude less stringent than provided by satellite measurements of planetary magnetic fields.

**Key words:** binaries: eclipsing – stars: early-type – stars: fundamental parameters – stars: individual: HV 982 – Magellanic Clouds

## 1 INTRODUCTION

The photographic light curves of eclipsing binary stars in the Large Magellanic Cloud (LMC) published by Gaposhkin (1970) suggest that the orbit of the star HV 982 is eccentric and close to edge on, and that the system is reasonably well detached. These properties should lead, ultimately, to very accurate estimates of the fundamental parameters of the component stars for comparison with theoretical models of stellar structure at low metallicity, and an accurate distance modulus for the LMC. We have therefore observed HV 982 as part of the campaign of improved CCD photometry of Magellanic Cloud eclipsing binaries that is underway at the Mount John University Observatory, Lake Tekapo, New Zealand (MJUO), and which has been described in the previous paper in this series [Pritchard et al. 1998 (Paper V)]. In this paper we present our optical photometry as well as *IUE* spectrophotometry of HV 982, and analyse these and other published data as far as is possible in the absence of spectroscopic velocity curves. This paper supersedes the preliminary discussion of our optical photometry (Pritchard, Tobin & Clark 1994) in which we announced the discovery of apsidal motion in HV 982. Apsidal motion offers the additional prospect of testing the components' internal mass distributions.

## 2 INSTRUMENTATION, OBSERVATIONS AND REDUCTIONS

The improved instrumentation and observation and reduction procedures have already been detailed in Paper V and in Pritchard (1997), so we only repeat the briefest details here. The optical photometry was obtained in $uvbyVI_{\mathrm{C}}$ between 1992 November and 1995 October using the MJUO McLellan 1-m Telescope at f/7.7 cassegrain focus in conjunction with a Photometrics PM3000 CCD detector system (Tobin 1992) and a computer-controlled photometer head (Tobin et al. 1993a). Additional differential measurements in $V$ were made around a predicted apsidally-shifted primary minimum on 1997 September 4. The CCD chip was a Thomson TH 7882 CDA chip overcoated with Metachrome II for blue and near-uv sensitivity; its 384×576 pixels each projected to $0''.62 \times 0''.62$ on the sky. To convert flat-fielding uncertain-

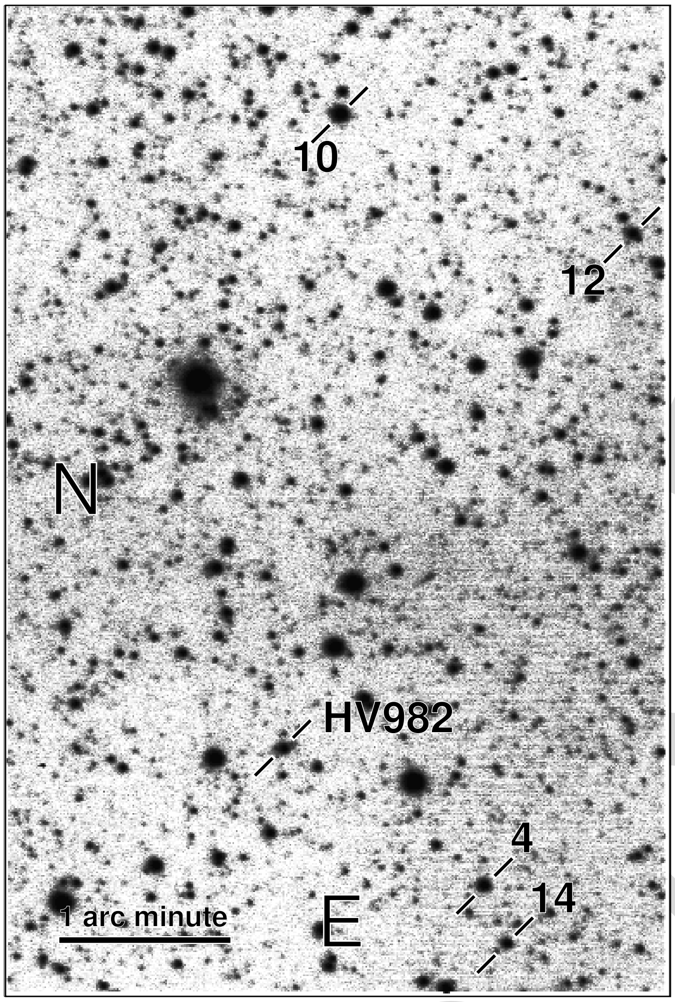


**Figure 1.** An $I_{\rm C}$-band image showing the adopted field positioning for HV 982 in the LMC. A comparison magnitude was provided by star 10 for $u$, $v$ and $b$ and by star 4 for $y$, $V$ and $I_{\rm C}$. Addition of the signals from stars 12 and 14 provided a check signal in all filters. An accurate position for HV 982 was obtained by differential measurement with respect to 9 adjacent stars in the Cape Photographic Catalogue 1950.0 (Stoy 1966), in the way described in Paper III (Tobin et al. 1993b). The 2000.0 coordinates are RA $05^{\rm h}29^{\rm m}52\overset{\rm s}{.}27\pm0\overset{\rm s}{.}19$, Dec. $-69°09'22\overset{''}{.}9\pm1\overset{''}{.}0$.

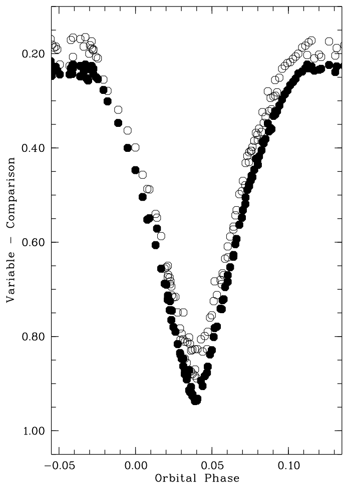


**Figure 2.** Open circles show photometry of the primary eclipse of HV 982 extracted with the fit of a single PSF to the composite image of HV 982 and three adjacent stars within $3-5$ arcsec. Filled circles show the much more consistent results obtained when the flux of the adjacent stars is subtracted, as described in the text.

ties into systematic offsets for differential photometry, we adopted a standard field placement which is shown in Figure 1. Instrumental magnitudes were extracted via profile fitting with DAOPHOT II (Stetson 1987). For the eclipsing binary, $V$ and $I_{\rm C}$ images were extracted so as to remove the flux of two stars $\sim$ 3 arcsec to the NNE and SSW and a third star $\sim$ 5 arcsec to the west. If the seeing was good enough for DAOPHOT to `FIND` these stars, they were PSF fitted conjointly with the image of HV 982; if not, their contribution to the image was subtracted on the basis of their known positions and magnitudes relative to the comparison star. Figure 2 compares instrumental magnitudes for HV 982 with and without these corrections and illustrates their importance. Besides HV 982, photometry was extracted for 14 other bright stars in the field, and comparison and check signals were derived from various of their fluxes, as described in the caption to Figure 1. ($Check - Comparison$) magnitudes showed negligible dependence on seeing. However clear effects at the few percent level were seen in the ($Variable - Comparison$) residuals from light-curve fits to the eclipsing binary in the $uvby$ differential photometry (for which no subtraction of the flux of nearby stars had been attempted). Linear corrections were applied. Seeing effects were also seen in $V$ and $I_{\rm C}$ for the poorest seeing despite the correction for nearby stars. Photometric points were deleted for FWHM seeings greater than $6\overset{''}{.}0$ and $5\overset{''}{.}0$ for $V$ and $I_{\rm C}$ respectively. The final differential photometry is reported in Table 1 and plotted in Figure 3. Typical exposure times and the quality of the photometry are summarized in Table 2. Our standard-system (absolute) photometry (Tables 3 & 4) derives from one set of target measures on each of 4 nights for $uvby$ and 2 measures on each of 2 nights for $VI_{\rm C}$. Details of the secondary standards, transformations etc. can be found in Paper V. Note that the $uvby$ photometry was reduced to $V$, $(b-y)$, $(u-b)$ and $(v-b)$, and values of $m_1$ and $c_1$ were derived therefrom. Two of the $uvby$ nights are thought to merit less weight than the others. The consistency of our results is disappointing. For example, the $V$ magnitudes derived from $y$ and $V$ filters are seen to disagree by $\sim$0.07 mag., which illustrates the difficulties inherent in crowded fields.

An *IUE* low-resolution uv spectrum with the SWP camera and large entrance aperture was obtained, as detailed in Table 5. The spectrum was reprocessed with the Final Archive (NEWSIPS) software in order to obtain improved spectral resolution and to correct for the variation of the camera sensitivity with temperature and time (e.g. Garhart 1992). The uncertainty in the reprocessed fluxes is estimated to be $\sim$5 per cent (Imhoff, priv. comm.).

**Table 1.** HV 982 differential photometry. The columns are Heliocentric Julian Day number (calculated on the basis of the UTC time of mid exposure), *Variable* − *Comparison* magnitude ($V - Cp$), airmass ($X$) and FWHM seeing in arcsec ($\sigma$).

| HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ***u*** | | | | | | | | | | | |
| 49164.8445 | 0.897 | 2.02 | 4.1 | 49170.2922 | 0.694 | 1.33 | 2.4 | 49218.1374 | 1.038 | 1.39 | 6.7 | 49245.1066 | 0.620 | 1.28 | 4.7 | 49512.1353 | 0.629 | 2.27 | 4.7 |
| 49164.8627 | 0.859 | 2.11 | 5.3 | 49170.8203 | 0.616 | 1.98 | 2.2 | 49218.1586 | 0.982 | 1.34 | 6.8 | 49245.1351 | 0.623 | 1.22 | 4.9 | 49512.1891 | 0.623 | 2.00 | 5.8 |
| 49164.8843 | 0.815 | 2.22 | 4.7 | 49172.9321 | 0.606 | 2.48 | 4.7 | 49218.1842 | 0.924 | 1.27 | 6.0 | 49245.1675 | 0.629 | 1.17 | 5.1 | 49512.2726 | 0.633 | 1.61 | 4.2 |
| 49164.9434 | 0.713 | 2.46 | 4.5 | 49172.9647 | 0.642 | 2.53 | 4.8 | 49218.2087 | 0.801 | 1.22 | 6.1 | 49245.2220 | 0.628 | 1.12 | 5.7 | 49517.8628 | 0.614 | 1.94 | 3.6 |
| 49164.9595 | 0.702 | 2.50 | 4.7 | 49172.9809 | 0.604 | 2.52 | 5.0 | 49218.2363 | 0.820 | 1.18 | 6.8 | 49246.8773 | 1.050 | 2.20 | 3.5 | 49562.9026 | 0.636 | 2.53 | 3.7 |
| 49165.0057 | 0.661 | 2.52 | 4.8 | 49190.9892 | 0.661 | 2.38 | 6.1 | 49220.0753 | 0.720 | 1.60 | 3.8 | 49246.9428 | 1.258 | 1.86 | 4.2 | 49562.9652 | 0.615 | 2.40 | 3.1 |
| 49167.9108 | 0.621 | 2.37 | 2.9 | 49191.0468 | 0.763 | 2.12 | 5.7 | 49220.0970 | 0.763 | 1.51 | 3.4 | 49247.0096 | 1.182 | 1.56 | 4.3 | 49563.1621 | 0.613 | 1.50 | 2.9 |
| 49167.9932 | 0.610 | 2.52 | 3.9 | 49193.0923 | 0.613 | 1.85 | 4.0 | 49237.8914 | 0.649 | 2.25 | 3.0 | 49247.0972 | 0.921 | 1.29 | 3.3 | 49563.9357 | 0.657 | 2.48 | 4.2 |
| 49168.0095 | 0.623 | 2.50 | 3.5 | 49193.1658 | 0.606 | 1.53 | 3.5 | 49237.9561 | 0.629 | 1.92 | 2.9 | 49247.1757 | 0.753 | 1.15 | 3.0 | 49564.1622 | 0.628 | 1.49 | 3.2 |
| 49168.0373 | 0.592 | 2.43 | 3.8 | 49193.2484 | 0.608 | 1.28 | 3.5 | 49238.0186 | 0.624 | 1.63 | 2.7 | 49313.9098 | 0.999 | 1.30 | 3.4 | 49564.1856 | 0.620 | 1.41 | 3.3 |
| 49169.8585 | 1.020 | 2.16 | 2.3 | 49196.0518 | 0.637 | 2.02 | 3.6 | 49238.8746 | 0.656 | 2.32 | 3.1 | 49313.9874 | 1.218 | 1.16 | 3.8 | 49564.2088 | 0.616 | 1.34 | 3.0 |
| 49169.8739 | 1.051 | 2.23 | 2.5 | 49196.1588 | 0.633 | 1.53 | 3.2 | 49238.8989 | 0.648 | 2.20 | 3.1 | 49314.1122 | 1.184 | 1.11 | 3.9 | 49591.0637 | 0.638 | 1.58 | 3.9 |
| 49169.8990 | 1.115 | 2.35 | 2.9 | 49214.8697 | 1.053 | 2.52 | 4.0 | 49238.9199 | 0.650 | 2.09 | 3.5 | 49406.8944 | 0.941 | 1.13 | 5.1 | 49598.0207 | 0.615 | 1.68 | 5.8 |
| 49169.9171 | 1.196 | 2.42 | 2.8 | 49214.9153 | 1.211 | 2.41 | 3.7 | 49238.9385 | 0.648 | 2.00 | 3.3 | 49426.0958 | 1.330 | 1.85 | 5.1 | 49598.0592 | 0.603 | 1.52 | 5.9 |
| 49169.9465 | 1.270 | 2.50 | 2.6 | 49214.9369 | 1.269 | 2.33 | 3.9 | 49238.9592 | 0.653 | 1.89 | 3.0 | 49433.9871 | 0.650 | 1.48 | 4.7 | 49598.0983 | 0.614 | 1.39 | 5.8 |
| 49169.9624 | 1.285 | 2.52 | 2.7 | 49214.9755 | 1.273 | 2.14 | 4.5 | 49238.9786 | 0.660 | 1.79 | 3.1 | 49434.0108 | 0.643 | 1.57 | 5.1 | 49598.1378 | 0.621 | 1.29 | 5.9 |
| 49169.9892 | 1.314 | 2.52 | 3.0 | 49214.9909 | 1.220 | 2.07 | 4.3 | 49238.9974 | 0.662 | 1.71 | 3.0 | 49434.0389 | 0.640 | 1.68 | 5.8 | 49598.1792 | 0.600 | 1.21 | 5.7 |
| 49170.0171 | 1.293 | 2.48 | 3.1 | 49215.0214 | 1.144 | 1.91 | 3.8 | 49239.0235 | 0.675 | 1.60 | 3.3 | 49434.0662 | 0.634 | 1.81 | 3.9 | 49598.2217 | 0.602 | 1.15 | 5.5 |
| 49170.0441 | 1.268 | 2.39 | 3.3 | 49215.0654 | 1.023 | 1.70 | 3.6 | 49239.0450 | 0.707 | 1.51 | 2.9 | 49434.0959 | 0.638 | 1.96 | 4.8 | 49598.8756 | 0.733 | 2.37 | 4.8 |
| 49170.0612 | 1.198 | 2.32 | 2.8 | 49215.0818 | 0.980 | 1.63 | 3.8 | 49239.0640 | 0.727 | 1.45 | 2.9 | 49434.1208 | 0.629 | 2.09 | 4.5 | 49599.2118 | 0.993 | 1.16 | 4.6 |
| 49170.0823 | 1.137 | 2.22 | 3.1 | 49215.1206 | 0.868 | 1.48 | 3.6 | 49239.0825 | 0.747 | 1.39 | 3.3 | 49434.1444 | 0.641 | 2.21 | 4.4 | 49600.2188 | 0.635 | 1.14 | 2.9 |
| 49170.0971 | 1.083 | 2.15 | 3.0 | 49215.1462 | 0.809 | 1.39 | 3.7 | 49239.1006 | 0.790 | 1.34 | 3.0 | 49434.1718 | 0.615 | 2.34 | 5.5 | 49628.1860 | 0.624 | 1.11 | 5.5 |
| 49170.1243 | 1.024 | 2.01 | 3.1 | 49215.1646 | 0.767 | 1.34 | 3.5 | 49239.1192 | 0.815 | 1.29 | 3.2 | 49434.2001 | 0.638 | 2.44 | 5.3 | 49717.0096 | 0.657 | 1.11 | 8.4 |
| 49170.1491 | 0.978 | 1.88 | 3.2 | 49215.2132 | 0.693 | 1.23 | 3.5 | 49239.1372 | 0.853 | 1.25 | 3.2 | 49434.2252 | 0.621 | 2.50 | 5.4 | 49717.0700 | 0.635 | 1.16 | 8.0 |
| 49170.1730 | 0.933 | 1.77 | 3.0 | 49215.2401 | 0.656 | 1.19 | 3.5 | 49239.1550 | 0.883 | 1.22 | 3.0 | 49511.8529 | 0.615 | 1.81 | 3.3 | | | | |
| 49170.1891 | 0.876 | 1.69 | 2.8 | 49215.2563 | 0.647 | 1.16 | 3.6 | 49239.1862 | 0.954 | 1.17 | 3.0 | 49511.8774 | 0.636 | 1.93 | 3.4 | | | | |
| 49170.2765 | 0.731 | 1.37 | 2.5 | 49218.1130 | 1.111 | 1.48 | 6.4 | 49239.2052 | 1.005 | 1.15 | 3.2 | 49512.0855 | 0.643 | 2.46 | 4.5 | | | | |
| | | | | | | | | ***v*** | | | | | | | | | | | |
| 49167.9331 | 1.106 | 2.45 | 2.8 | 49193.2084 | 1.105 | 1.39 | 3.2 | 49247.1920 | 1.223 | 1.14 | 2.8 | 49453.0553 | 1.186 | 2.02 | 4.0 | 49598.1526 | 1.091 | 1.25 | 5.6 |
| 49168.0533 | 1.097 | 2.38 | 3.4 | 49196.0892 | 1.130 | 1.83 | 3.6 | 49313.9259 | 1.524 | 1.26 | 3.4 | 49511.9012 | 1.131 | 2.05 | 3.6 | 49598.2477 | 1.075 | 1.13 | 5.1 |
| 49168.0697 | 1.112 | 2.31 | 3.6 | 49196.2214 | 1.130 | 1.33 | 2.9 | 49314.0035 | 1.730 | 1.14 | 3.6 | 49512.1113 | 1.123 | 2.38 | 5.6 | 49598.8962 | 1.241 | 2.28 | 3.7 |
| 49168.0847 | 1.111 | 2.24 | 3.7 | 49237.9088 | 1.120 | 2.16 | 2.9 | 49314.1283 | 1.608 | 1.12 | 4.6 | 49512.2322 | 1.151 | 1.79 | 5.6 | 49599.2271 | 1.422 | 1.14 | 4.3 |
| 49170.8757 | 1.095 | 2.26 | 2.5 | 49237.9713 | 1.132 | 1.85 | 3.1 | 49406.9119 | 1.472 | 1.15 | 4.7 | 49562.9176 | 1.125 | 2.52 | 3.4 | 49600.2334 | 1.112 | 1.13 | 2.4 |
| 49172.9969 | 1.090 | 2.50 | 4.9 | 49238.0347 | 1.118 | 1.56 | 3.0 | 49425.9284 | 1.497 | 1.25 | 4.9 | 49562.9798 | 1.101 | 2.35 | 3.0 | 49628.1713 | 1.096 | 1.12 | 5.1 |
| 49173.0131 | 1.091 | 2.47 | 5.3 | 49246.8924 | 1.585 | 2.12 | 3.2 | 49425.9715 | 1.572 | 1.36 | 5.5 | 49563.1768 | 1.102 | 1.45 | 2.9 | 49717.0268 | 1.097 | 1.12 | 7.3 |
| 49173.0287 | 1.106 | 2.42 | 6.0 | 49246.9584 | 1.758 | 1.79 | 3.9 | 49426.1124 | 1.774 | 1.93 | 4.9 | 49563.9504 | 1.109 | 2.44 | 3.7 | 49717.0865 | 1.123 | 1.18 | 7.9 |
| 49173.0453 | 1.100 | 2.36 | 5.6 | 49247.0272 | 1.619 | 1.50 | 3.9 | 49452.9737 | 1.303 | 1.63 | 3.7 | 49591.0800 | 1.118 | 1.52 | 3.6 | | | | |
| 49193.1269 | 1.108 | 1.69 | 3.5 | 49247.1141 | 1.379 | 1.25 | 3.5 | 49453.0151 | 1.241 | 1.81 | 3.9 | 49598.0354 | 1.087 | 1.62 | 5.3 | | | | |
| | | | | | | | | ***b*** | | | | | | | | | | | |
| 49167.9539 | 1.156 | 2.50 | 2.8 | 49196.1254 | 1.183 | 1.66 | 3.1 | 49313.9440 | 1.628 | 1.23 | 3.5 | 49453.0704 | 1.236 | 2.10 | 4.3 | 49598.0743 | 1.153 | 1.47 | 5.3 |
| 49168.1007 | 1.167 | 2.16 | 3.4 | 49196.2548 | 1.174 | 1.25 | 2.4 | 49314.0209 | 1.823 | 1.13 | 3.4 | 49512.0148 | 1.192 | 2.51 | 4.0 | 49598.1940 | 1.151 | 1.18 | 5.1 |
| 49168.1164 | 1.185 | 2.08 | 3.2 | 49237.9881 | 1.192 | 1.76 | 2.8 | 49314.1500 | 1.601 | 1.13 | 4.4 | 49512.1628 | 1.181 | 2.14 | 4.6 | 49598.2625 | 1.098 | 1.12 | 5.3 |
| 49168.1314 | 1.168 | 2.00 | 3.2 | 49238.0505 | 1.196 | 1.50 | 2.7 | 49406.9295 | 1.576 | 1.17 | 5.0 | 49512.2471 | 1.205 | 1.72 | 4.9 | 49598.9197 | 1.353 | 2.17 | 4.3 |
| 49170.8905 | 1.161 | 2.32 | 2.4 | 49246.9074 | 1.692 | 2.05 | 3.2 | 49425.9441 | 1.560 | 1.29 | 5.1 | 49562.9324 | 1.188 | 2.50 | 2.9 | 49599.2419 | 1.444 | 1.13 | 4.6 |
| 49173.0606 | 1.168 | 2.29 | 5.2 | 49246.9752 | 1.827 | 1.71 | 4.1 | 49425.9903 | 1.700 | 1.42 | 5.6 | 49562.9943 | 1.187 | 2.28 | 2.7 | 49600.2479 | 1.163 | 1.12 | 2.3 |
| 49173.0817 | 1.183 | 2.19 | 6.0 | 49247.0548 | 1.612 | 1.41 | 3.3 | 49426.1281 | 1.781 | 2.01 | 5.4 | 49563.1915 | 1.163 | 1.40 | 2.9 | 49628.1567 | 1.165 | 1.13 | 4.8 |
| 49173.0973 | 1.201 | 2.11 | 6.4 | 49247.1297 | 1.412 | 1.22 | 3.3 | 49452.9901 | 1.347 | 1.70 | 3.7 | 49563.9650 | 1.179 | 2.39 | 3.8 | 49717.0416 | 1.190 | 1.13 | 7.9 |
| 49173.1125 | 1.165 | 2.03 | 6.0 | 49247.2068 | 1.266 | 1.13 | 2.7 | 49453.0303 | 1.285 | 1.89 | 3.8 | 49591.0949 | 1.177 | 1.46 | 3.7 | 49717.1019 | 1.211 | 1.20 | 8.4 |
| | | | | | | | | ***y*** | | | | | | | | | | | |
| 49167.8950 | 0.197 | 2.30 | 2.6 | 49238.0011 | 0.190 | 1.71 | 2.6 | 49314.1642 | 0.595 | 1.15 | 4.6 | 49512.0625 | 0.204 | 2.51 | 4.3 | 49598.2337 | 0.206 | 1.14 | 5.3 |
| 49167.9717 | 0.184 | 2.52 | 2.8 | 49238.0624 | 0.191 | 1.46 | 2.5 | 49406.9414 | 0.626 | 1.18 | 5.2 | 49512.2112 | 0.206 | 1.89 | 5.4 | 49598.9392 | 0.414 | 2.07 | 5.0 |
| 49168.1514 | 0.190 | 1.90 | 2.9 | 49246.9192 | 0.751 | 1.99 | 3.2 | 49425.9577 | 0.593 | 1.32 | 4.8 | 49512.2589 | 0.208 | 1.67 | 4.1 | 49599.2538 | 0.426 | 1.12 | 5.2 |
| 49168.1610 | 0.184 | 1.86 | 3.1 | 49246.9873 | 0.835 | 1.66 | 4.3 | 49426.0513 | 0.835 | 1.64 | 6.1 | 49562.9449 | 0.192 | 2.47 | 3.1 | 49600.2072 | 0.190 | 1.16 | 2.2 |
| 49170.9023 | 0.196 | 2.37 | 2.2 | 49247.0669 | 0.594 | 1.37 | 3.2 | 49426.0655 | 0.843 | 1.70 | 5.8 | 49563.0061 | 0.184 | 2.23 | 2.6 | 49628.0925 | 0.221 | 1.22 | 4.8 |
| 49196.1769 | 0.197 | 1.47 | 2.8 | 49247.1420 | 0.403 | 1.20 | 3.3 | 49426.1405 | 0.754 | 2.07 | 5.5 | 49563.2036 | 0.193 | 1.37 | 2.8 | 49628.1447 | 0.216 | 1.14 | 5.0 |
| 49196.1894 | 0.207 | 1.42 | 2.6 | 49247.2195 | 0.261 | 1.12 | 2.8 | 49453.0029 | 0.359 | 1.75 | 3.8 | 49563.9767 | 0.215 | 2.35 | 4.0 | 49717.0545 | 0.201 | 1.14 | 8.0 |
| 49196.2053 | 0.188 | 1.38 | 2.5 | 49313.9571 | 0.710 | 1.21 | 3.9 | 49453.0425 | 0.289 | 1.95 | 3.9 | 49591.1405 | 0.260 | 1.33 | 3.0 | 49717.1144 | 0.193 | 1.22 | 8.4 |
| 49237.9368 | 0.187 | 2.03 | 2.6 | 49314.0331 | 0.880 | 1.12 | 3.8 | 49453.0824 | 0.259 | 2.15 | 4.5 | 49598.1101 | 0.198 | 1.36 | 5.3 | | | | |
| | | | | | | | | ***V*** | | | | | | | | | | | |
| 48953.9794 | 0.230 | 1.15 | 4.8 | 49015.9196 | 0.241 | 1.11 | 2.9 | 49019.0874 | 0.204 | 1.36 | 3.4 | 49042.0888 | 0.604 | 1.58 | 4.2 | 49073.8840 | 0.780 | 1.24 | 3.7 |
| 48953.9976 | 0.235 | 1.14 | 4.7 | 49015.9321 | 0.227 | 1.11 | 2.5 | 49019.0938 | 0.211 | 1.38 | 3.9 | 49054.9217 | 0.858 | 1.21 | 2.2 | 49073.8911 | 0.790 | 1.25 | 4.1 |
| 48954.0107 | 0.239 | 1.13 | 5.1 | 49015.9591 | 0.236 | 1.13 | 2.6 | 49019.1014 | 0.215 | 1.40 | 3.3 | 49054.9381 | 0.805 | 1.24 | 2.3 | 49073.8988 | 0.816 | 1.27 | 3.7 |
| 48954.0300 | 0.228 | 1.11 | 5.3 | 49015.9997 | 0.220 | 1.17 | 2.3 | 49019.1071 | 0.204 | 1.42 | 3.5 | 49054.9455 | 0.780 | 1.25 | 2.1 | 49073.9188 | 0.847 | 1.31 | 5.2 |
| 48954.0552 | 0.229 | 1.11 | 5.8 | 49016.0066 | 0.229 | 1.18 | 2.8 | 49019.1159 | 0.230 | 1.45 | 3.4 | 49054.9724 | 0.698 | 1.32 | 2.1 | 49073.9418 | 0.918 | 1.38 | 5.5 |
| 48954.0763 | 0.221 | 1.10 | 3.2 | 49016.0124 | 0.235 | 1.18 | 2.9 | 49019.1233 | 0.219 | 1.48 | 3.7 | 49054.9838 | 0.660 | 1.35 | 2.3 | 49073.9502 | 0.926 | 1.40 | 5.2 |
| 48954.1099 | 0.224 | 1.11 | 4.0 | 49016.0198 | 0.234 | 1.20 | 3.0 | 49037.9413 | 0.197 | 1.17 | 3.7 | 49054.9946 | 0.640 | 1.38 | 2.1 | 49073.9592 | 0.937 | 1.43 | 5.8 |
| 48954.1338 | 0.224 | 1.13 | 4.0 | 49016.0264 | 0.241 | 1.21 | 3.2 | 49037.9509 | 0.205 | 1.18 | 3.1 | 49055.0073 | 0.582 | 1.42 | 2.6 | 49073.9677 | 0.932 | 1.46 | 5.5 |
| 48954.1607 | 0.228 | 1.16 | 3.9 | 49016.0340 | 0.241 | 1.22 | 3.5 | 49037.9807 | 0.206 | 1.23 | 3.3 | 49055.0148 | 0.561 | 1.44 | 2.6 | 49073.9858 | 0.905 | 1.52 | 3.9 |
| 48954.1759 | 0.223 | 1.14 | 3.4 | 49016.0431 | 0.222 | 1.24 | 2.1 | 49038.0182 | 0.212 | 1.32 | 3.5 | 49055.0227 | 0.542 | 1.47 | 2.4 | 49073.9933 | 0.884 | 1.55 | 4.4 |
| 49014.0353 | 0.225 | 1.21 | 4.3 | 49016.0488 | 0.229 | 1.25 | 2.2 | 49038.0395 | 0.210 | 1.37 | 3.5 | 49055.0283 | 0.523 | 1.49 | 2.5 | 49074.0037 | 0.864 | 1.59 | 4.0 |
| 49014.0490 | 0.228 | 1.24 | 4.7 | 49016.0721 | 0.223 | 1.30 | 2.1 | 49038.0527 | 0.208 | 1.41 | 3.8 | 49055.0344 | 0.511 | 1.51 | 2.5 | 49074.0116 | 0.838 | 1.62 | 4.3 |
| 49014.0934 | 0.234 | 1.34 | 4.2 | 49016.0838 | 0.230 | 1.33 | 2.3 | 49038.0668 | 0.213 | 1.46 | 3.8 | 49055.0428 | 0.498 | 1.54 | 2.5 | 49074.0180 | 0.829 | 1.65 | 4.2 |
| 49014.1063 | 0.240 | 1.38 | 5.3 | 49016.1188 | 0.221 | 1.43 | 2.3 | 49038.0800 | 0.210 | 1.51 | 3.9 | 49055.0628 | 0.439 | 1.62 | 2.9 | 49074.0245 | 0.801 | 1.68 | 4.2 |
| 49014.1163 | 0.235 | 1.41 | 4.7 | 49016.1460 | 0.224 | 1.53 | 2.3 | 49038.0953 | 0.209 | 1.56 | 3.7 | 49055.0876 | 0.388 | 1.73 | 2.8 | 49074.0358 | 0.779 | 1.73 | 3.9 |
| 49014.1234 | 0.233 | 1.43 | 5.0 | 49016.1541 | 0.226 | 1.56 | 2.7 | 49038.1077 | 0.205 | 1.61 | 3.9 | 49055.0943 | 0.370 | 1.76 | 2.8 | 49074.0482 | 0.741 | 1.79 | 3.7 |
| 49014.1346 | 0.219 | 1.47 | 4.4 | 49016.1601 | 0.222 | 1.58 | 2.4 | 49038.1242 | 0.212 | 1.68 | 3.5 | 49055.1096 | 0.357 | 1.84 | 3.0 | 49074.0554 | 0.723 | 1.82 | 3.6 |
| 49014.1457 | 0.220 | 1.51 | 4.7 | 49016.1662 | 0.228 | 1.61 | 2.6 | 49038.1358 | 0.213 | 1.74 | 3.5 | 49055.1193 | 0.316 | 1.88 | 3.1 | 49074.0643 | 0.695 | 1.87 | 3.8 |
| 49014.1645 | 0.221 | 1.58 | 4.7 | 49016.1725 | 0.223 | 1.63 | 2.4 | 49038.1530 | 0.206 | 1.82 | 3.9 | 49055.1308 | 0.305 | 1.94 | 3.1 | 49074.0734 | 0.670 | 1.91 | 3.8 |
| 49014.1709 | 0.216 | 1.60 | 4.6 | 49016.1789 | 0.224 | 1.66 | 2.7 | 49041.8973 | 0.839 | 1.13 | 2.4 | 49055.1385 | 0.292 | 1.98 | 3.0 | 49074.0820 | 0.653 | 1.96 | 4.4 |
| 49014.9526 | 0.277 | 1.12 | 2.7 | 49016.1845 | 0.223 | 1.69 | 2.7 | 49041.9122 | 0.880 | 1.15 | 2.2 | 49055.1446 | 0.282 | 2.01 | 3.0 | 49074.0937 | 0.627 | 2.02 | 4.0 |
| 49014.9668 | 0.301 | 1.13 | 2.4 | 49018.9133 | 0.221 | 1.11 | 3.8 | 49041.9192 | 0.891 | 1.16 | 2.2 | 49055.1508 | 0.276 | 2.05 | 3.1 | 49074.1043 | 0.593 | 2.07 | 4.4 |
| 49015.0041 | 0.347 | 1.17 | 2.8 | 49018.9228 | 0.227 | 1.11 | 3.3 | 49041.9273 | 0.914 | 1.17 | 2.4 | 49073.0849 | 0.230 | 1.96 | 4.2 | 49074.1139 | 0.563 | 2.12 | 4.6 |
| 49015.0368 | 0.400 | 1.22 | 3.2 | 49018.9351 | 0.221 | 1.12 | 3.6 | 49041.9336 | 0.918 | 1.17 | 2.7 | 49073.0943 | 0.232 | 2.01 | 5.1 | 49074.1230 | 0.548 | 2.17 | 4.0 |
| 49015.0641 | 0.447 | 1.28 | 3.6 | 49018.9499 | 0.219 | 1.13 | 3.2 | 49041.9393 | 0.923 | 1.18 | 2.8 | 49073.1052 | 0.226 | 2.06 | 4.6 | 49074.1349 | 0.519 | 2.23 | 3.4 |
| 49015.0892 | 0.504 | 1.34 | 3.4 | 49018.9614 | 0.225 | 1.13 | 3.1 | 49041.9467 | 0.932 | 1.19 | 3.0 | 49073.1110 | 0.221 | 2.09 | 4.6 | 49074.1473 | 0.478 | 2.29 | 3.8 |
| 49015.1127 | 0.549 | 1.40 | 4.4 | 49018.9713 | 0.220 | 1.14 | 2.9 | 49041.9546 | 0.936 | 1.21 | 2.8 | 49073.1169 | 0.235 | 2.12 | 4.3 | 49074.1565 | 0.459 | 2.33 | 4.2 |
| 49015.1344 | 0.606 | 1.48 | 4.4 | 49018.9950 | 0.213 | 1.17 | 3.3 | 49041.9899 | 0.877 | 1.27 | 3.1 | 49073.1236 | 0.214 | 2.16 | 4.5 | 49074.1717 | 0.423 | 2.39 | 4.5 |
| 49015.1538 | 0.656 | 1.55 | 4.1 | 49019.0025 | 0.221 | 1.18 | 3.3 | 49042.0414 | 0.742 | 1.41 | 3.5 | 49073.1298 | 0.232 | 2.19 | 5.0 | 49074.1786 | 0.436 | 2.42 | 4.2 |
| 49015.1773 | 0.713 | 1.64 | 3.9 | 49019.0161 | 0.217 | 1.20 | 3.4 | 49042.0480 | 0.721 | 1.43 | 3.6 | 49073.1394 | 0.210 | 2.24 | 5.8 | 49074.1915 | 0.405 | 2.46 | 3.6 |
| 49015.1835 | 0.744 | 1.67 | 4.2 | 49019.0274 | 0.214 | 1.22 | 3.6 | 49042.0622 | 0.684 | 1.48 | 3.4 | 49073.8642 | 0.722 | 1.20 | 3.3 | 49074.1990 | 0.390 | 2.48 | 3.8 |
| 49015.1894 | 0.765 | 1.70 | 4.3 | 49019.0487 | 0.215 | 1.27 | 3.5 | 49042.0817 | 0.631 | 1.55 | 3.9 | 49073.8739 | 0.744 | 1.22 | 3.7 | 49074.2053 | 0.381 | 2.49 | 4.0 |

**continued on next page.**

**Table 1.** (cont).

| HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***V*** | | | | | | | | | | | | | | | | | | | |
| 49074.2172 | 0.365 | 2.52 | 3.9 | 49094.9400 | 0.232 | 1.56 | 4.3 | 49131.2407 | 0.209 | 1.97 | 2.9 | 49193.0518 | 0.219 | 2.07 | 2.9 | 49425.9174 | 0.552 | 1.23 | 4.7 |
| 49074.2264 | 0.360 | 2.53 | 3.7 | 49094.9457 | 0.232 | 1.59 | 4.3 | 49131.2465 | 0.213 | 1.94 | 2.8 | 49193.0598 | 0.218 | 2.03 | 2.7 | 49426.0840 | 0.936 | 1.78 | 3.9 |
| 49074.2331 | 0.332 | 2.53 | 3.8 | 49094.9552 | 0.250 | 1.63 | 4.3 | 49137.0544 | 0.215 | 2.52 | 4.2 | 49193.0809 | 0.220 | 1.92 | 3.5 | 49426.1522 | 0.782 | 2.13 | 5.9 |
| 49074.2394 | 0.329 | 2.53 | 4.0 | 49094.9614 | 0.254 | 1.65 | 4.4 | 49137.0602 | 0.221 | 2.53 | 4.6 | 49193.1031 | 0.222 | 1.81 | 3.4 | 49428.1892 | 0.421 | 2.33 | 3.0 |
| 49074.2457 | 0.322 | 2.53 | 3.8 | 49095.9027 | 0.222 | 1.44 | 3.0 | 49137.0662 | 0.218 | 2.53 | 5.0 | 49193.1130 | 0.220 | 1.76 | 3.0 | 49428.1949 | 0.441 | 2.36 | 2.6 |
| 49074.8870 | 0.218 | 1.25 | 2.1 | 49095.9119 | 0.223 | 1.47 | 3.2 | 49137.0717 | 0.212 | 2.53 | 4.6 | 49193.1421 | 0.223 | 1.63 | 2.7 | 49428.2013 | 0.449 | 2.38 | 2.7 |
| 49074.9059 | 0.215 | 1.29 | 2.4 | 49095.9181 | 0.221 | 1.49 | 3.3 | 49137.0773 | 0.210 | 2.53 | 4.5 | 49193.1512 | 0.224 | 1.59 | 3.0 | 49428.2069 | 0.475 | 2.40 | 2.7 |
| 49074.9256 | 0.221 | 1.34 | 2.9 | 49095.9244 | 0.221 | 1.51 | 3.4 | 49137.0829 | 0.212 | 2.52 | 4.6 | 49193.1884 | 0.225 | 1.46 | 2.5 | 49428.2124 | 0.488 | 2.42 | 2.8 |
| 49074.9297 | 0.218 | 1.35 | 2.7 | 49095.9302 | 0.228 | 1.54 | 3.5 | 49137.0884 | 0.219 | 2.52 | 4.8 | 49193.1941 | 0.230 | 1.44 | 2.8 | 49428.2182 | 0.504 | 2.44 | 2.9 |
| 49074.9313 | 0.210 | 1.35 | 2.7 | 49095.9362 | 0.223 | 1.56 | 3.3 | 49137.0940 | 0.218 | 2.51 | 4.2 | 49193.2198 | 0.219 | 1.36 | 3.2 | 49428.2237 | 0.534 | 2.46 | 3.0 |
| 49074.9328 | 0.215 | 1.36 | 2.8 | 49095.9420 | 0.227 | 1.58 | 3.5 | 49137.1027 | 0.211 | 2.49 | 4.4 | 49193.2299 | 0.231 | 1.33 | 2.9 | 49428.2294 | 0.528 | 2.47 | 2.9 |
| 49074.9344 | 0.227 | 1.36 | 3.1 | 49095.9484 | 0.221 | 1.61 | 3.3 | 49137.1083 | 0.219 | 2.48 | 4.5 | 49193.2619 | 0.230 | 1.26 | 3.0 | 49433.9769 | 0.273 | 1.44 | 3.2 |
| 49074.9457 | 0.219 | 1.39 | 2.2 | 49095.9545 | 0.235 | 1.63 | 3.3 | 49137.1180 | 0.226 | 2.45 | 4.2 | 49193.2711 | 0.227 | 1.24 | 2.6 | 49434.0007 | 0.245 | 1.52 | 3.9 |
| 49074.9472 | 0.224 | 1.40 | 2.2 | 49095.9599 | 0.228 | 1.66 | 3.8 | 49137.1248 | 0.220 | 2.43 | 3.8 | 49193.2807 | 0.226 | 1.22 | 2.5 | 49434.0247 | 0.237 | 1.62 | 4.2 |
| 49074.9488 | 0.212 | 1.40 | 2.2 | 49098.9466 | 0.215 | 1.63 | 5.1 | 49137.1339 | 0.204 | 2.40 | 3.8 | 49193.2899 | 0.232 | 1.20 | 2.3 | 49434.0548 | 0.229 | 1.75 | 3.1 |
| 49074.9503 | 0.221 | 1.41 | 2.4 | 49098.9592 | 0.198 | 1.69 | 5.0 | 49137.1395 | 0.226 | 2.38 | 4.1 | 49193.2961 | 0.245 | 1.19 | 2.5 | 49434.0856 | 0.227 | 1.90 | 3.4 |
| 49074.9555 | 0.228 | 1.42 | 2.6 | 49098.9745 | 0.210 | 1.76 | 4.3 | 49137.1521 | 0.238 | 2.33 | 3.8 | 49196.0633 | 0.244 | 1.97 | 3.1 | 49434.1098 | 0.216 | 2.02 | 4.1 |
| 49074.9571 | 0.216 | 1.43 | 2.5 | 49128.9846 | 0.212 | 2.23 | 3.8 | 49137.8493 | 0.571 | 1.67 | 3.0 | 49196.0735 | 0.235 | 1.91 | 3.0 | 49434.1344 | 0.230 | 2.15 | 3.6 |
| 49074.9586 | 0.214 | 1.43 | 2.6 | 49128.9902 | 0.212 | 2.25 | 3.8 | 49137.8760 | 0.688 | 1.79 | 3.2 | 49196.0997 | 0.240 | 1.79 | 3.2 | 49434.1617 | 0.224 | 2.28 | 4.0 |
| 49074.9602 | 0.204 | 1.44 | 2.5 | 49128.9960 | 0.213 | 2.28 | 3.7 | 49137.8819 | 0.690 | 1.82 | 3.5 | 49196.1106 | 0.247 | 1.73 | 3.0 | 49434.1882 | 0.211 | 2.39 | 4.2 |
| 49074.9639 | 0.232 | 1.45 | 2.3 | 49129.0138 | 0.204 | 2.36 | 4.0 | 49137.8880 | 0.715 | 1.85 | 3.7 | 49196.1358 | 0.244 | 1.62 | 2.8 | 49434.2149 | 0.242 | 2.48 | 4.1 |
| 49074.9655 | 0.208 | 1.46 | 2.5 | 49129.0209 | 0.215 | 2.39 | 4.3 | 49137.8948 | 0.725 | 1.89 | 3.2 | 49196.1450 | 0.242 | 1.59 | 2.7 | 49511.8388 | 0.223 | 1.73 | 2.8 |
| 49074.9670 | 0.220 | 1.46 | 2.6 | 49129.0273 | 0.223 | 2.41 | 4.4 | 49137.9011 | 0.745 | 1.92 | 3.0 | 49196.1693 | 0.247 | 1.49 | 2.4 | 49511.8635 | 0.236 | 1.85 | 3.1 |
| 49074.9686 | 0.227 | 1.47 | 2.9 | 49129.0332 | 0.214 | 2.43 | 3.7 | 49137.9296 | 0.835 | 2.07 | 3.7 | 49196.1979 | 0.244 | 1.40 | 2.7 | 49511.8875 | 0.232 | 1.97 | 2.7 |
| 49074.9737 | 0.213 | 1.48 | 3.2 | 49129.0409 | 0.208 | 2.46 | 3.4 | 49137.9354 | 0.847 | 2.10 | 3.6 | 49196.2317 | 0.244 | 1.31 | 2.2 | 49511.9366 | 0.239 | 2.22 | 3.0 |
| 49074.9753 | 0.215 | 1.49 | 2.8 | 49129.0487 | 0.205 | 2.48 | 3.8 | 49137.9410 | 0.863 | 2.13 | 3.8 | 49196.2413 | 0.243 | 1.28 | 2.3 | 49512.0009 | 0.222 | 2.47 | 3.9 |
| 49074.9768 | 0.215 | 1.50 | 2.7 | 49129.0560 | 0.204 | 2.50 | 3.9 | 49137.9465 | 0.872 | 2.15 | 4.0 | 49196.2687 | 0.248 | 1.23 | 2.3 | 49512.0249 | 0.226 | 2.52 | 4.1 |
| 49074.9784 | 0.213 | 1.50 | 2.8 | 49129.0775 | 0.200 | 2.53 | 3.5 | 49137.9554 | 0.884 | 2.20 | 4.4 | 49196.2748 | 0.247 | 1.22 | 2.1 | 49512.0699 | 0.243 | 2.50 | 5.3 |
| 49074.9837 | 0.214 | 1.52 | 2.9 | 49129.0830 | 0.206 | 2.53 | 3.6 | 49137.9615 | 0.871 | 2.23 | 4.2 | 49196.2901 | 0.252 | 1.19 | 2.3 | 49512.0959 | 0.226 | 2.44 | 4.4 |
| 49074.9915 | 0.216 | 1.55 | 3.1 | 49129.0886 | 0.207 | 2.53 | 3.5 | 49137.9682 | 0.907 | 2.26 | 4.5 | 49196.2966 | 0.257 | 1.18 | 2.4 | 49512.1217 | 0.243 | 2.34 | 4.3 |
| 49074.9986 | 0.221 | 1.58 | 3.5 | 49129.0972 | 0.212 | 2.53 | 4.0 | 49138.0028 | 0.894 | 2.41 | 5.1 | 49214.8395 | 0.572 | 2.52 | 3.2 | 49512.1456 | 0.217 | 2.23 | 3.9 |
| 49075.1411 | 0.199 | 2.27 | 3.0 | 49129.1032 | 0.221 | 2.53 | 3.9 | 49163.8432 | 0.223 | 1.99 | 4.3 | 49214.8460 | 0.593 | 2.52 | 2.8 | 49512.1743 | 0.233 | 2.09 | 4.4 |
| 49075.1503 | 0.215 | 2.32 | 3.1 | 49129.1092 | 0.207 | 2.52 | 4.0 | 49163.8524 | 0.219 | 2.03 | 4.9 | 49214.8518 | 0.600 | 2.53 | 2.9 | 49512.2002 | 0.226 | 1.95 | 4.6 |
| 49075.1579 | 0.203 | 2.35 | 2.9 | 49129.1187 | 0.220 | 2.51 | 4.1 | 49163.8772 | 0.224 | 2.16 | 4.7 | 49214.8838 | 0.706 | 2.50 | 3.0 | 49512.2825 | 0.223 | 1.57 | 3.5 |
| 49075.1634 | 0.199 | 2.37 | 3.5 | 49129.1282 | 0.203 | 2.49 | 3.6 | 49166.8138 | 0.554 | 1.88 | 3.3 | 49214.8900 | 0.733 | 2.49 | 3.2 | 49517.8117 | 0.213 | 1.68 | 3.6 |
| 49075.1649 | 0.224 | 2.37 | 2.9 | 49129.1340 | 0.209 | 2.47 | 3.6 | 49166.8277 | 0.591 | 1.95 | 3.4 | 49214.8980 | 0.759 | 2.47 | 3.6 | 49562.8886 | 0.222 | 2.52 | 2.9 |
| 49075.1665 | 0.221 | 2.38 | 3.0 | 49129.1411 | 0.209 | 2.45 | 3.8 | 49166.8340 | 0.611 | 1.98 | 3.2 | 49215.9887 | 0.184 | 2.07 | 3.7 | 49562.9522 | 0.206 | 2.45 | 2.9 |
| 49075.1680 | 0.218 | 2.39 | 3.0 | 49129.1471 | 0.206 | 2.43 | 3.6 | 49166.8408 | 0.625 | 2.02 | 3.3 | 49216.0010 | 0.202 | 2.01 | 4.1 | 49563.1487 | 0.221 | 1.55 | 2.3 |
| 49075.1707 | 0.203 | 2.40 | 2.8 | 49129.1663 | 0.204 | 2.36 | 3.6 | 49166.8478 | 0.657 | 2.05 | 3.4 | 49216.0080 | 0.211 | 1.97 | 3.8 | 49563.9182 | 0.211 | 2.52 | 3.9 |
| 49075.1722 | 0.232 | 2.40 | 2.8 | 49129.1751 | 0.217 | 2.32 | 4.2 | 49166.8667 | 0.694 | 2.15 | 3.4 | 49216.0187 | 0.198 | 1.92 | 4.1 | 49564.1491 | 0.233 | 1.54 | 2.6 |
| 49075.1738 | 0.210 | 2.41 | 2.7 | 49129.1810 | 0.208 | 2.30 | 3.5 | 49166.8732 | 0.724 | 2.18 | 3.3 | 49216.0250 | 0.194 | 1.88 | 4.0 | 49564.1723 | 0.232 | 1.46 | 2.6 |
| 49075.1753 | 0.215 | 2.41 | 2.7 | 49129.1886 | 0.208 | 2.26 | 2.7 | 49166.8791 | 0.738 | 2.21 | 2.9 | 49242.0130 | 0.274 | 0.00 | 0.0 | 49564.1957 | 0.227 | 1.38 | 2.6 |
| 49075.1796 | 0.214 | 2.43 | 2.9 | 49129.1942 | 0.222 | 2.23 | 2.9 | 49166.8849 | 0.804 | 2.24 | 3.0 | 49242.0324 | 0.235 | 0.00 | 0.0 | 49591.0498 | 0.231 | 1.64 | 3.0 |
| 49075.1811 | 0.199 | 2.43 | 2.8 | 49129.1998 | 0.210 | 2.21 | 3.0 | 49166.8930 | 0.811 | 2.28 | 3.2 | 49242.0392 | 0.237 | 0.00 | 3.5 | 49598.0070 | 0.216 | 1.75 | 4.2 |
| 49075.1827 | 0.228 | 2.44 | 2.9 | 49129.2053 | 0.210 | 2.18 | 2.8 | 49166.8989 | 0.804 | 2.31 | 3.3 | 49244.8534 | 0.532 | 2.34 | 4.8 | 49598.0456 | 0.222 | 1.58 | 4.6 |
| 49075.1842 | 0.212 | 2.44 | 2.7 | 49129.2111 | 0.210 | 2.15 | 3.0 | 49166.9047 | 0.834 | 2.33 | 3.3 | 49244.8628 | 0.505 | 2.30 | 5.5 | 49598.0847 | 0.216 | 1.44 | 4.6 |
| 49075.1890 | 0.209 | 2.46 | 2.9 | 49129.2168 | 0.215 | 2.12 | 2.8 | 49166.9120 | 0.847 | 2.36 | 3.5 | 49244.8687 | 0.489 | 2.27 | 5.7 | 49598.1235 | 0.210 | 1.33 | 5.7 |
| 49075.1905 | 0.221 | 2.46 | 2.9 | 49129.2225 | 0.209 | 2.09 | 2.8 | 49168.1918 | 0.209 | 1.71 | 3.0 | 49244.8753 | 0.481 | 2.24 | 5.5 | 49598.1648 | 0.211 | 1.23 | 4.7 |
| 49075.1921 | 0.204 | 2.47 | 3.1 | 49129.2283 | 0.213 | 2.06 | 2.9 | 49168.1973 | 0.204 | 1.69 | 2.9 | 49244.8809 | 0.469 | 2.22 | 4.9 | 49598.2083 | 0.222 | 1.16 | 4.5 |
| 49075.1936 | 0.229 | 2.47 | 3.0 | 49129.2349 | 0.219 | 2.03 | 2.9 | 49168.2030 | 0.202 | 1.66 | 3.0 | 49244.8867 | 0.462 | 2.19 | 5.0 | 49598.8613 | 0.330 | 2.43 | 3.7 |
| 49075.1995 | 0.215 | 2.49 | 3.0 | 49129.2412 | 0.220 | 1.99 | 3.1 | 49168.2123 | 0.206 | 1.62 | 2.8 | 49244.8932 | 0.446 | 2.15 | 4.8 | 49598.8860 | 0.361 | 2.34 | 4.1 |
| 49075.2057 | 0.211 | 2.50 | 3.0 | 49129.2643 | 0.210 | 1.88 | 2.9 | 49168.2179 | 0.207 | 1.60 | 2.9 | 49244.9042 | 0.425 | 2.10 | 4.6 | 49598.9063 | 0.403 | 2.24 | 3.7 |
| 49091.8445 | 0.222 | 1.25 | 2.3 | 49129.2700 | 0.216 | 1.85 | 3.0 | 49168.2234 | 0.208 | 1.58 | 3.0 | 49244.9099 | 0.418 | 2.07 | 4.7 | 49598.9300 | 0.466 | 2.12 | 4.1 |
| 49091.9137 | 0.231 | 1.44 | 3.1 | 49129.2761 | 0.225 | 1.82 | 2.8 | 49168.2334 | 0.198 | 1.54 | 2.9 | 49244.9218 | 0.387 | 2.01 | 5.3 | 49598.9465 | 0.494 | 2.04 | 4.7 |
| 49091.9195 | 0.238 | 1.46 | 2.9 | 49129.8805 | 0.238 | 1.71 | 3.9 | 49168.2388 | 0.199 | 1.52 | 2.8 | 49244.9403 | 0.348 | 1.91 | 5.8 | 49599.1566 | 0.760 | 1.24 | 3.4 |
| 49091.9264 | 0.233 | 1.48 | 3.3 | 49129.8876 | 0.244 | 1.75 | 3.6 | 49168.2441 | 0.201 | 1.50 | 2.8 | 49244.9499 | 0.358 | 1.86 | 5.4 | 49599.1625 | 0.750 | 1.23 | 3.3 |
| 49091.9410 | 0.245 | 1.54 | 3.3 | 49129.8931 | 0.236 | 1.77 | 3.5 | 49168.2496 | 0.204 | 1.48 | 2.7 | 49244.9657 | 0.322 | 1.79 | 5.9 | 49599.1680 | 0.727 | 1.22 | 3.1 |
| 49091.9474 | 0.244 | 1.56 | 3.3 | 49129.8989 | 0.236 | 1.80 | 3.3 | 49168.2631 | 0.207 | 1.43 | 2.8 | 49244.9807 | 0.310 | 1.72 | 5.3 | 49599.1740 | 0.699 | 1.21 | 3.3 |
| 49091.9543 | 0.251 | 1.59 | 3.3 | 49129.9054 | 0.230 | 1.83 | 4.0 | 49168.2686 | 0.204 | 1.42 | 3.2 | 49244.9901 | 0.297 | 1.67 | 6.0 | 49599.1834 | 0.679 | 1.20 | 3.2 |
| 49091.9607 | 0.262 | 1.62 | 3.5 | 49129.9109 | 0.231 | 1.86 | 3.9 | 49168.2740 | 0.201 | 1.40 | 2.7 | 49244.9997 | 0.286 | 1.63 | 5.4 | 49599.1923 | 0.653 | 1.18 | 3.9 |
| 49091.9676 | 0.265 | 1.64 | 3.5 | 49129.9163 | 0.221 | 1.89 | 3.6 | 49168.2795 | 0.204 | 1.38 | 2.7 | 49245.0089 | 0.278 | 1.60 | 5.3 | 49599.2015 | 0.614 | 1.17 | 3.6 |
| 49091.9732 | 0.276 | 1.67 | 3.9 | 49130.0036 | 0.225 | 1.89 | 4.6 | 49168.2849 | 0.206 | 1.37 | 2.7 | 49245.0182 | 0.267 | 1.56 | 4.8 | 49600.1967 | 0.218 | 1.17 | 2.5 |
| 49091.9796 | 0.278 | 1.70 | 3.8 | 49130.0092 | 0.228 | 1.89 | 4.3 | 49168.2905 | 0.209 | 1.35 | 2.7 | 49245.0284 | 0.260 | 1.52 | 4.7 | 49628.0817 | 0.224 | 1.24 | 3.8 |
| 49092.1519 | 0.645 | 2.48 | 3.5 | 49130.0146 | 0.234 | 1.89 | 4.7 | 49168.2962 | 0.202 | 1.34 | 2.6 | 49245.0374 | 0.253 | 1.49 | 4.6 | 49628.1342 | 0.233 | 1.15 | 4.0 |
| 49092.1574 | 0.654 | 2.50 | 3.1 | 49130.0208 | 0.234 | 1.89 | 4.8 | 49170.9098 | 0.223 | 2.40 | 2.2 | 49245.0467 | 0.242 | 1.45 | 4.1 | 49631.0763 | 0.836 | 1.23 | 3.0 |
| 49092.1633 | 0.678 | 2.51 | 3.0 | 49130.0279 | 0.221 | 1.89 | 3.9 | 49170.9258 | 0.220 | 2.45 | 2.3 | 49245.0600 | 0.238 | 1.41 | 4.8 | 49631.0819 | 0.859 | 1.22 | 2.8 |
| 49092.1690 | 0.693 | 2.52 | 3.1 | 49130.0341 | 0.222 | 1.89 | 4.2 | 49170.9328 | 0.219 | 2.47 | 2.5 | 49245.0713 | 0.231 | 1.38 | 4.8 | 49631.0880 | 0.861 | 1.21 | 2.9 |
| 49092.1746 | 0.710 | 2.52 | 3.1 | 49130.0397 | 0.236 | 1.89 | 4.3 | 49190.8303 | 0.216 | 2.29 | 4.9 | 49245.0828 | 0.231 | 1.35 | 5.4 | 49631.0935 | 0.893 | 1.20 | 3.4 |
| 49092.1871 | 0.748 | 2.53 | 4.3 | 49130.0595 | 0.226 | 1.89 | 4.8 | 49190.8359 | 0.226 | 2.32 | 4.7 | 49245.0927 | 0.227 | 1.32 | 5.4 | 49631.0990 | 0.897 | 1.19 | 3.4 |
| 49092.2015 | 0.778 | 2.53 | 4.2 | 49130.0684 | 0.209 | 1.89 | 5.0 | 49190.8429 | 0.233 | 2.35 | 4.8 | 49245.1192 | 0.234 | 1.26 | 4.2 | 49631.1046 | 0.912 | 1.18 | 3.2 |
| 49092.9498 | 0.224 | 1.58 | 2.8 | 49130.0796 | 0.216 | 1.89 | 4.4 | 49190.8484 | 0.228 | 2.37 | 4.5 | 49245.1540 | 0.224 | 1.19 | 5.0 | 49631.1100 | 0.916 | 1.17 | 2.9 |
| 49092.9559 | 0.224 | 1.61 | 2.9 | 49130.2288 | 0.217 | 2.04 | 3.1 | 49190.8539 | 0.236 | 2.39 | 4.7 | 49245.1806 | 0.227 | 1.16 | 3.9 | 49631.1155 | 0.893 | 1.17 | 2.8 |
| 49092.9614 | 0.219 | 1.63 | 3.1 | 49130.2357 | 0.210 | 2.01 | 3.0 | 49190.9009 | 0.231 | 2.51 | 5.8 | 49245.2073 | 0.226 | 1.13 | 4.4 | 49631.1210 | 0.916 | 1.16 | 2.7 |
| 49092.9689 | 0.224 | 1.66 | 2.9 | 49130.2413 | 0.215 | 1.98 | 3.2 | 49190.9088 | 0.223 | 2.52 | 5.6 | 49246.9299 | 0.826 | 1.94 | 3.1 | 49631.1265 | 0.895 | 1.15 | 2.7 |
| 49092.9754 | 0.220 | 1.69 | 2.8 | 49130.2471 | 0.229 | 1.95 | 3.0 | 49190.9343 | 0.226 | 2.52 | 5.5 | 49246.9982 | 0.854 | 1.62 | 3.6 | 49631.1319 | 0.874 | 1.15 | 2.6 |
| 49092.9810 | 0.234 | 1.72 | 3.2 | 49130.2527 | 0.220 | 1.92 | 3.2 | 49190.9458 | 0.238 | 2.51 | 5.4 | 49247.0791 | 0.589 | 1.34 | 3.0 | 49631.1374 | 0.868 | 1.14 | 2.5 |
| 49092.9866 | 0.219 | 1.74 | 3.1 | 49130.2589 | 0.220 | 1.89 | 3.7 | 49190.9516 | 0.223 | 2.50 | 5.6 | 49247.1647 | 0.382 | 1.17 | 2.6 | 49631.1428 | 0.842 | 1.14 | 2.7 |
| 49092.9924 | 0.222 | 1.77 | 2.9 | 49130.2651 | 0.214 | 1.86 | 3.6 | 49190.9677 | 0.233 | 2.46 | 5.0 | 49247.2328 | 0.267 | 1.11 | 3.0 | 49631.1483 | 0.836 | 1.13 | 2.4 |
| 49092.9978 | 0.223 | 1.79 | 2.9 | 49131.2242 | 0.214 | 2.05 | 3.0 | 49190.9735 | 0.226 | 2.44 | 5.0 | 49247.9366 | 0.220 | 1.89 | 3.3 | 49631.1538 | 0.800 | 1.13 | 2.5 |
| 49093.0036 | 0.220 | 1.82 | 3.0 | 49131.2301 | 0.217 | 2.02 | 2.7 | 49190.9791 | 0.243 | 2.43 | 5.0 | 49247.9422 | 0.216 | 1.86 | 3.4 | 49712.9940 | 0.231 | 1.11 | 3.6 |
| 49094.9311 | 0.228 | 1.53 | 3.5 | 49131.2354 | 0.206 | 1.99 | 2.6 | 49193.0447 | 0.227 | 2.11 | 3.2 | 49247.9477 | 0.211 | 1.83 | 3.3 | 49713.0092 | 0.220 | 1.11 | 4.0 |
| ***$I_C$*** | | | | | | | | | | | | | | | | | | | |
| 49072.8926 | 0.444 | 1.25 | 3.5 | 49168.1436 | 0.428 | 1.95 | 2.7 | 49170.1998 | 0.667 | 1.65 | 2.2 | 49193.0708 | 0.423 | 1.97 | 3.3 | 49196.1402 | 0.431 | 1.61 | 2.6 |
| 49072.9014 | 0.435 | 1.26 | 3.7 | 49168.1458 | 0.445 | 1.94 | 2.6 | 49170.2021 | 0.669 | 1.64 | 2.2 | 49193.0757 | 0.435 | 1.95 | 3.1 | 49196.1496 | 0.437 | 1.57 | 2.7 |
| 49072.9224 | 0.431 | 1.31 | 4.4 | 49169.8851 | 0.904 | 2.28 | 1.9 | 49170.2044 | 0.656 | 1.64 | 2.2 | 49193.1081 | 0.439 | 1.79 | 3.4 | 49196.1832 | 0.425 | 1.45 | 2.6 |
| 49072.9309 | 0.436 | 1.34 | 5.0 | 49169.8889 | 0.917 | 2.30 | 2.3 | 49170.2672 | 0.572 | 1.40 | 2.3 | 49193.1175 | 0.437 | 1.74 | 2.6 | 49196.2114 | 0.418 | 1.36 | 2.8 |
| 49072.9472 | 0.462 | 1.38 | 4.9 | 49169.9326 | 1.048 | 2.46 | 2.1 | 49170.8402 | 0.443 | 2.07 | 2.1 | 49193.1467 | 0.452 | 1.61 | 2.8 | 49196.2368 | 0.427 | 1.29 | 2.4 |
| 49072.9538 | 0.429 | 1.40 | 4.7 | 49169.9375 | 1.065 | 2.47 | 1.9 | 49170.8465 | 0.436 | 2.10 | 2.2 | 49193.1565 | 0.441 | 1.57 | 2.7 | 49196.2458 | 0.431 | 1.27 | 2.2 |
| 49072.9586 | 0.439 | 1.42 | 5.0 | 49169.9765 | 1.130 | 2.53 | 2.1 | 49170.8516 | 0.439 | 2.13 | 2.0 | 49193.1986 | 0.446 | 1.42 | 2.7 | 49196.2643 | 0.445 | 1.24 | 2.3 |
| 49072.9698 | 0.413 | 1.45 | 4.7 | 49169.9804 | 1.137 | 2.53 | 2.3 | 49170.8610 | 0.418 | 2.17 | 1.7 | 49193.2254 | 0.453 | 1.34 | 2.8 | 49196.2795 | 0.444 | 1.21 | 2.3 |
| 49072.9757 | 0.428 | 1.47 | 4.4 | 49170.0288 | 1.123 | 2.45 | 2.3 | 49170.8660 | 0.439 | 2.20 | 1.8 | 49193.2352 | 0.445 | 1.32 | 2.8 | 49214.8567 | 0.849 | 2.53 | 3.0 |
| 49072.9857 | 0.435 | 1.51 | 4.9 | 49170.0353 | 1.109 | 2.43 | 2.6 | 49170.9181 | 0.431 | 2.42 | 2.1 | 49193.2388 | 0.449 | 1.31 | 3.3 | 49214.8603 | 0.853 | 2.53 | 2.6 |
| 49072.9905 | 0.419 | 1.53 | 4.9 | 49170.0704 | 0.986 | 2.29 | 2.4 | 49172.8958 | 0.436 | 2.36 | 3.2 | 49193.2666 | 0.438 | 1.25 | 3.0 | 49214.9028 | 0.977 | 2.46 | 2.9 |
| 49072.9944 | 0.421 | 1.54 | 4.8 | 49170.0730 | 0.970 | 2.28 | 2.4 | 49172.9067 | 0.441 | 2.40 | 3.8 | 49193.2756 | 0.466 | 1.23 | 2.8 | 49214.9062 | 1.013 | 2.45 | 3.0 |
| 49072.9996 | 0.440 | 1.56 | 4.6 | 49170.1100 | 0.869 | 2.10 | 2.3 | 49172.9152 | 0.444 | 2.43 | 4.2 | 49193.2854 | 0.454 | 1.21 | 2.6 | 49214.9468 | 1.114 | 2.29 | 3.0 |
| 49073.0034 | 0.450 | 1.58 | 4.8 | 49170.1120 | 0.866 | 2.09 | 3.0 | 49172.9208 | 0.445 | 2.45 | 4.0 | 49196.0410 | 0.445 | 2.09 | 3.0 | 49214.9507 | 1.110 | 2.28 | 3.4 |
| 49073.0082 | 0.438 | 1.60 | 4.7 | 49170.1154 | 0.877 | 2.07 | 2.3 | 49190.8257 | 0.418 | 2.27 | 4.3 | 49196.0682 | 0.439 | 1.94 | 2.9 | 49214.9600 | 1.108 | 2.23 | 3.1 |
| 49073.0135 | 0.425 | 1.62 | 4.5 | 49170.1612 | 0.735 | 1.83 | 2.3 | 49190.9598 | 0.430 | 2.48 | 4.9 | 49196.0792 | 0.431 | 1.89 | 2.8 | 49214.9662 | 1.124 | 2.20 | 3.5 |
| 49167.9635 | 0.450 | 2.51 | 2.3 | 49170.1644 | 0.748 | 1.82 | 2.6 | 49190.9633 | 0.428 | 2.47 | 4.5 | 49196.1061 | 0.436 | 1.76 | 3.0 | 49215.0013 | 1.030 | 2.02 | 3.1 |
| 49168.1401 | 0.431 | 1.97 | 2.8 | 49170.1978 | 0.675 | 1.66 | 2.5 | 49191.0193 | 0.485 | 2.26 | 4.9 | 49196.1161 | 0.441 | 1.71 | 2.8 | 49215.0049 | 0.999 | 2.00 | 3.1 |

**continued on next page.**

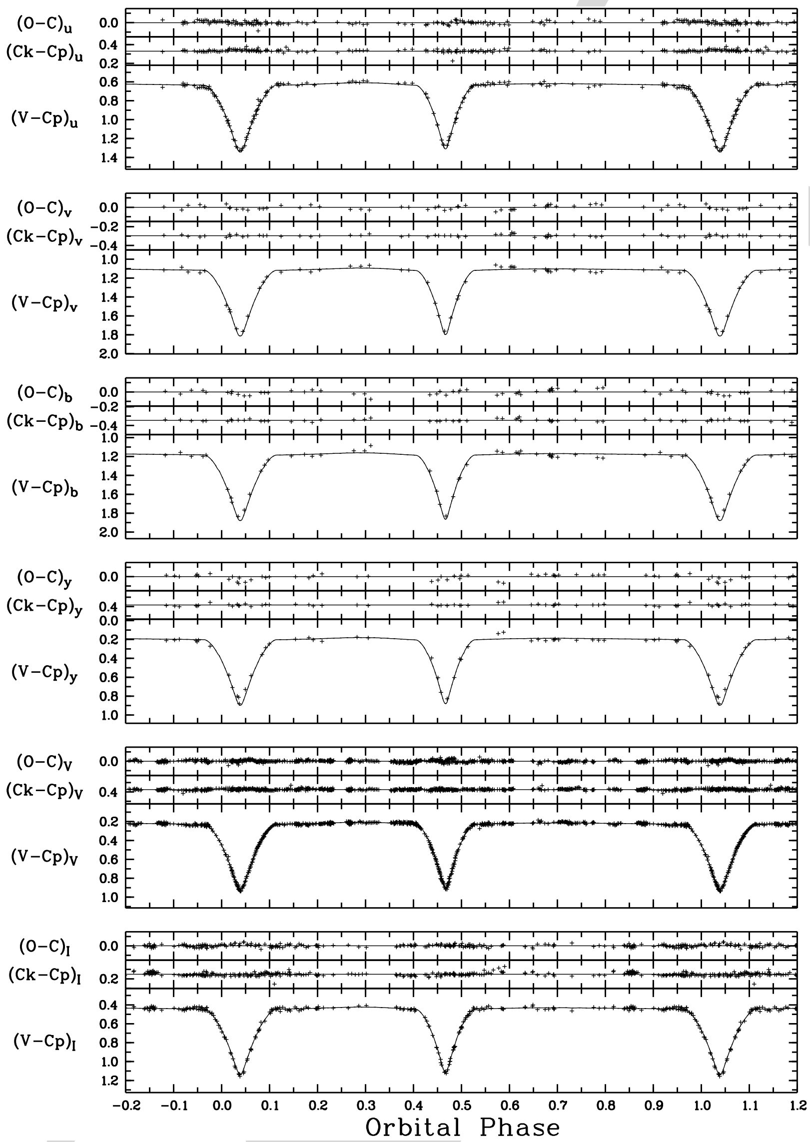


**Figure 3.** A typical WD code fit to the light curves of HV 982, phased according to the linear ephemeris derived in Section 3.1. Plotted are the $Variable - Comparison$ $(V - Cp)$ differential light curve observations, model light curves (lines), $Check - Comparison$ $(Ck - Cp)$ differential magnitudes and the residuals between Observations and model Computations $(O - C)$ for each bandpass ($uvbyVI_{\rm C}$).

**Table 1.** (cont).

| HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ | HJD −2400000 | $V-Cp$ | X | $\sigma$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | $I_{\rm C}$ | | | | | | | | | | |
| 49215.0086 | 0.997 | 1.98 | 3.3 | 49238.0084 | 0.437 | 1.68 | 2.4 | 49245.0331 | 0.447 | 1.50 | 4.2 | 49434.0811 | 0.458 | 1.88 | 3.1 | 49563.9260 | 0.456 | 2.51 | 3.9 |
| 49215.0120 | 0.967 | 1.97 | 3.2 | 49238.0686 | 0.432 | 1.45 | 2.1 | 49245.0421 | 0.457 | 1.47 | 4.1 | 49434.1054 | 0.433 | 2.00 | 3.5 | 49564.1534 | 0.454 | 1.52 | 2.7 |
| 49215.0455 | 0.875 | 1.80 | 3.3 | 49238.8652 | 0.443 | 2.36 | 2.3 | 49245.0512 | 0.449 | 1.44 | 4.1 | 49434.1298 | 0.450 | 2.13 | 3.9 | 49564.1768 | 0.461 | 1.44 | 2.8 |
| 49215.0493 | 0.847 | 1.78 | 3.1 | 49238.8896 | 0.452 | 2.26 | 2.6 | 49245.0762 | 0.434 | 1.36 | 4.8 | 49434.1573 | 0.424 | 2.26 | 4.0 | 49564.2000 | 0.451 | 1.37 | 2.7 |
| 49215.0526 | 0.852 | 1.76 | 2.9 | 49238.9105 | 0.448 | 2.15 | 2.7 | 49245.0882 | 0.449 | 1.33 | 4.2 | 49434.1809 | 0.412 | 2.37 | 4.7 | 49591.0548 | 0.458 | 1.62 | 3.5 |
| 49215.0561 | 0.842 | 1.75 | 2.8 | 49238.9293 | 0.443 | 2.06 | 2.5 | 49245.0972 | 0.433 | 1.31 | 4.1 | 49434.2106 | 0.435 | 2.47 | 4.4 | 49598.0115 | 0.434 | 1.73 | 4.5 |
| 49215.1080 | 0.697 | 1.53 | 3.1 | 49238.9502 | 0.456 | 1.95 | 2.7 | 49245.1258 | 0.428 | 1.25 | 4.2 | 49511.8439 | 0.446 | 1.75 | 2.6 | 49598.1287 | 0.411 | 1.31 | 4.9 |
| 49215.1113 | 0.685 | 1.52 | 3.0 | 49238.9684 | 0.461 | 1.86 | 2.5 | 49245.1585 | 0.425 | 1.19 | 4.5 | 49511.8678 | 0.442 | 1.87 | 3.2 | 49598.2127 | 0.407 | 1.16 | 4.8 |
| 49215.1299 | 0.645 | 1.45 | 2.9 | 49238.9878 | 0.463 | 1.76 | 2.1 | 49245.1866 | 0.444 | 1.15 | 4.0 | 49511.8922 | 0.470 | 2.00 | 2.7 | 49598.8666 | 0.534 | 2.41 | 4.1 |
| 49215.1334 | 0.636 | 1.44 | 3.0 | 49239.0140 | 0.482 | 1.64 | 2.3 | 49245.2124 | 0.459 | 1.13 | 4.0 | 49511.9928 | 0.451 | 2.45 | 3.2 | 49598.9107 | 0.625 | 2.22 | 4.0 |
| 49215.1371 | 0.630 | 1.43 | 2.9 | 49239.0329 | 0.495 | 1.57 | 2.1 | 49246.9254 | 1.037 | 1.96 | 3.1 | 49512.0051 | 0.463 | 2.48 | 3.7 | 49598.9508 | 0.723 | 2.02 | 4.8 |
| 49215.1553 | 0.580 | 1.37 | 2.9 | 49239.0543 | 0.512 | 1.49 | 2.5 | 49246.9936 | 1.087 | 1.64 | 4.1 | 49512.0563 | 0.423 | 2.52 | 3.4 | 49599.1784 | 0.878 | 1.21 | 3.5 |
| 49215.1785 | 0.551 | 1.31 | 3.0 | 49239.0733 | 0.554 | 1.42 | 2.6 | 49247.0747 | 0.839 | 1.35 | 3.0 | 49512.0745 | 0.436 | 2.49 | 4.5 | 49599.1878 | 0.850 | 1.19 | 3.3 |
| 49215.1821 | 0.536 | 1.30 | 2.9 | 49239.0915 | 0.573 | 1.37 | 2.6 | 49247.1531 | 0.644 | 1.19 | 2.7 | 49512.1021 | 0.462 | 2.42 | 4.5 | 49599.1970 | 0.842 | 1.18 | 3.4 |
| 49215.2004 | 0.516 | 1.26 | 2.8 | 49239.1100 | 0.615 | 1.32 | 2.9 | 49247.2280 | 0.512 | 1.11 | 2.6 | 49512.1262 | 0.451 | 2.32 | 4.1 | 49600.2013 | 0.448 | 1.17 | 2.2 |
| 49215.2038 | 0.511 | 1.25 | 3.5 | 49239.1282 | 0.645 | 1.27 | 2.5 | 49313.9636 | 0.971 | 1.20 | 3.7 | 49512.1512 | 0.443 | 2.21 | 4.0 | 49628.0864 | 0.434 | 1.23 | 4.4 |
| 49215.2267 | 0.473 | 1.21 | 2.8 | 49239.1462 | 0.686 | 1.24 | 2.3 | 49314.0408 | 1.156 | 1.12 | 3.2 | 49512.1790 | 0.422 | 2.07 | 4.5 | 49628.1387 | 0.445 | 1.15 | 4.5 |
| 49215.2301 | 0.496 | 1.20 | 2.5 | 49239.1726 | 0.740 | 1.19 | 2.4 | 49406.9481 | 0.908 | 1.19 | 4.7 | 49512.2050 | 0.431 | 1.93 | 4.4 | 49712.0173 | 0.424 | 1.11 | 3.5 |
| 49215.2663 | 0.431 | 1.15 | 3.3 | 49239.1773 | 0.739 | 1.18 | 2.3 | 49426.0786 | 1.137 | 1.76 | 4.2 | 49512.2867 | 0.438 | 1.56 | 3.4 | 49712.0201 | 0.423 | 1.11 | 3.3 |
| 49215.2696 | 0.453 | 1.15 | 2.8 | 49239.1957 | 0.766 | 1.16 | 2.5 | 49433.9723 | 0.470 | 1.42 | 3.7 | 49517.8172 | 0.434 | 1.71 | 3.3 | 49712.0998 | 0.415 | 1.18 | 3.5 |
| 49220.0855 | 0.572 | 1.56 | 3.1 | 49244.9168 | 0.584 | 2.04 | 4.9 | 49433.9961 | 0.466 | 1.50 | 4.2 | 49562.8935 | 0.445 | 2.52 | 2.8 | 49712.1049 | 0.400 | 1.18 | 3.9 |
| 49220.1061 | 0.625 | 1.49 | 2.8 | 49245.0138 | 0.475 | 1.58 | 4.9 | 49434.0200 | 0.435 | 1.60 | 4.2 | 49562.9564 | 0.443 | 2.44 | 2.6 | 49712.9991 | 0.433 | 1.11 | 4.3 |
| 49237.9461 | 0.426 | 1.98 | 2.4 | 49245.0227 | 0.489 | 1.54 | 4.4 | 49434.0493 | 0.436 | 1.72 | 2.8 | 49563.1530 | 0.463 | 1.54 | 2.3 | 49713.0041 | 0.417 | 1.11 | 4.4 |

**Table 3.** Absolute *uvby* photometry of HV 982. (Values for *IUE* phases.) The quoted total errors are the quadratic sums of the internal and transformation uncertainties.

| Date | $V$ | $(b-y)$ | $(u-b)$ | $(v-b)$ | $m_1$ | $c_1$ | Weight |
|---|---|---|---|---|---|---|---|
| 1995 Sep 18 | 14.719 | 0.002 | 0.131 | 0.010 | 0.008 | 0.111 | 0.5 |
| 1995 Sep 19 | 14.670 | −0.074 | 0.101 | 0.059 | 0.133 | −0.017 | 1 |
| 1997 Jun 01 | 14.621 | 0.007 | 0.082 | −0.059 | −0.066 | 0.201 | 0.5 |
| 1997 Jun 05 | 14.696 | 0.097 | −0.115 | −0.092 | −0.189 | 0.070 | 1 |
| Weighted mean | 14.679 | 0.009 | 0.031 | −0.019 | −0.028 | 0.070 | |
| Internal error | ±0.018 | ±0.040 | ±0.060 | ±0.038 | ±0.077 | ±0.043 | |
| Total error | ±0.026 | ±0.041 | ±0.062 | ±0.039 | ±0.078 | ±0.045 | |

**Table 2.** Typical exposure durations, signal levels and precisions achieved for the differential photometry of HV 982.

| | $u$ | $v$ | $b$ | $y$ | $V$ | $I_C$ |
|---|---|---|---|---|---|---|
| **TYPICAL EXPOSURE TIMES** (in seconds) | | | | | | |
| | 1200 | 1200 | 1200 | 700 | 400 | 200 |
| **SIGNAL LEVELS**[a] | | | | | | |
| **Variable**[b] | −10.5 | −10.3 | −10.7 | −10.9 | −12.1 | −10.7 |
| **Comp** (10) | −11.1 | −11.4 | −11.8 | | | |
| (4) | | | | −11.1 | −12.3 | −11.0 |
| **Check** (12+14) | −11.1 | −10.9 | −11.3 | −11.5 | −12.7 | −11.3 |
| **R.M.S. PRECISIONS** (in magnitudes) | | | | | | |
| **Var-Comp**[c] | 0.016 | 0.018 | 0.021 | 0.015 | 0.011 | 0.014 |
| **Check-Comp** | 0.010 | 0.012 | 0.012 | 0.011 | 0.007 | 0.013 |

[a] Reported in instrumental magnitudes $= -2.5\log_{10}$(ADU above background).
[b] Outside eclipse.
[c] With respect to WD code solutions.

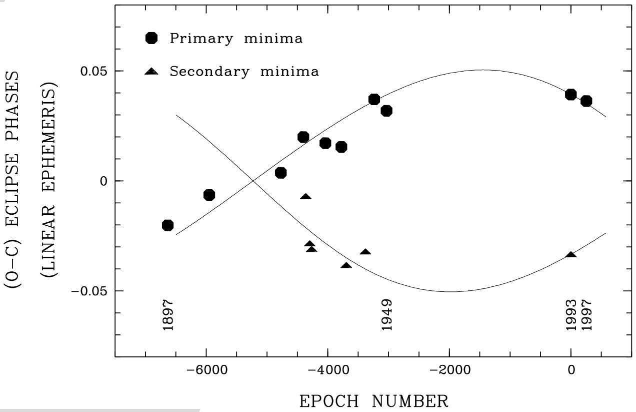


**Figure 4.** Apsidal motion analysis of HV 982. The deviations of a century of observed timings from a linear ephemeris (points) should be compared with the fit (full lines) corresponding to the parameters given in Table 6 and mean values of $i$, $\omega_0$ and $e$ for the cases reported in Table 8. The r.m.s. deviation of the older, photographic timings about the fitted curves is 60 min.

**Table 4.** Absolute $VI_C$ photometry of HV 982. (Values for *IUE* phases.) The quoted total errors are the quadratic sums of the internal and transformation uncertainties.

| Date | $V$ | $I_C$ | $(V-I_C)$ | Weight |
|---|---|---|---|---|
| 1994 Dec 26 | 14.599 | 14.764 | −0.165 | 1 |
| 1994 Dec 26 | 14.602 | 14.741 | −0.140 | 1 |
| 1995 Feb 12 | 14.621 | 14.711 | −0.092 | 1 |
| 1995 Feb 12 | 14.624 | 14.716 | −0.091 | 1 |
| Weighted mean | 14.612 | 14.733 | −0.122 | |
| Internal error | ±0.011 | ±0.017 | ±0.028 | |
| Total error | ±0.016 | ±0.035 | ±0.043 | |

## 3 ANALYSIS

### 3.1 Ephemerides

The unevenly spaced eclipses of different width clearly reveal that HV 982 is in an eccentric orbit. In Table 6 we report two representative minima $T_1$ and $T_2$ derived from the 1992-95 observations plus a more recent minimum $T_1'$ observed on 1997 September 4. Apsidal motion is apparent when our timings are combined with the 13 minima between 1897 and 1949 reported by Gaposhkin (1977) (Figure 4). Using values of $i$, $\omega_0$ and $e$ determined from our light curves solutions (see below), we have determined the Epoch $T_0$ and the sidereal and anomalistic periods $P_s$ and $P_a$ by fitting the observed times of minima with Eq. 20 of Gimènez & Garcia-Pelayo (1983) using the Levenberg-Marquardt method (Press et al. 1989). For the Gaposchkin timings, we adopted an uncertainty of 90 min, which we consider representative based on analysis of other systems (Watson et al. 1992, Tobin et al. 1993b). The values of $T_0$, $P_s$ and $P_a$ reported in Table 6, along with the corresponding apsidal period $U$, are representative of the results obtained for the four light curve solutions detailed later. The fit is shown in Figure 4. The full ephemeris for HV 982 is given by Eq. 20 of Giménez & Garcia-Pelayo (1983) substituting numerical values reported in Table 6; however, the light curves plotted in this paper, *IUE* phases, light-curve analyses, etc., all use a simpler, linear ephemeris based on $T_0$ and $P_s$.

**Table 5.** Details of the *IUE* low-resolution spectrophotometry of HV 982.

| Image Groundstation | Exposure start (UTC) | Duration (s) | Middle (HJD) Phase[a] |
|---|---|---|---|
| SWP 50009 | 1994 Feb 13 | 5999.7 | 2449397.1125 |
| Goddard | 13:52:28 | | 0.6088 |

[a] Calculated according to a linear ephemeris based on the values of $T_0$ and $P_s$ given in Table 6.

### 3.2 Interstellar reddening and extinction

The optical reddening laws of the Galaxy and both Magellanic Clouds are similar (e.g. Bouchet et al. 1985) and the Kurucz model atmospheres (1993) indicate that the optical colours of B stars are insensitive to metallicity. We therefore determined the total reddening $E(b-y)$ to HV 982 in the standard way in the $(b-y)/c_1$ diagram (Figure 5) using the

**Table 6.** Minima timings and ephemeris for HV 982.

| Parameter | Value | |
|---|---|---|
| **Derived from our photometry** | | |
| Representative primary (deeper) minimum, $T_1$ | HJD 2449335.3866 $\pm0.0004$ | |
| Representative secondary (shallower) minimum, $T_2$ | HJD 2449337.6668 $\pm0.0004$ | |
| More recent primary minimum (1997 Sept 4), $T_1'$ | HJD 2450695.852 $\pm0.011$ | |
| **Derived from timings 1897–1997** | | |
| Epoch, $T_0$ | HJD 2449335.1770 $\pm0.0004$ | |
| Sidereal period, $P_s$ | 5.335220 d $\pm0.000003$ | |
| Anomalistic period, $P_a$ | 5.33560 d $\pm0.00001$ | |
| Apsidal period, $U$ | 75 000 d $\pm2\,500$ | 205 yr $\pm7$ |
| Rate of advance of periastron, $\dot{\omega}$ | 1.76 °/yr $\pm0.02$ | |

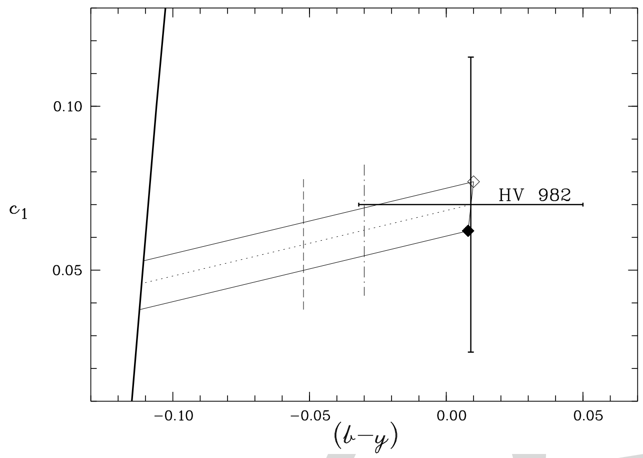


**Figure 5.** Total reddening to HV 982. The total reddening $E(b-y) = 0.12 \pm 0.05$ is derived from the displacement of the colours of the components for the example case 2 in Table 8 (diamonds) from the empirical $(b-y)$ vs $c_0$ relation for B stars (Crawford 1978, heavy line) and a reddening ratio $E(c_1)/E(b-y) = 0.2$ (Crawford 1975). For components this hot, this reddening differs negligibly from the value that would be obtained using the composite photometry (represented by the error bar cross and dotted line) and so does not depend on the precise component light ratios. Also indicated are the foreground reddening (dashed line) and reddening to infinity (dot-dashed line), as reported in Table 7 and explained in the text.

empirical $(b-y)/c_0$ relation tabulated by Crawford (1978). For this, the observed composite colours at the *IUE* phases were deconvolved to the colours of the individual stars using light ratios implied by our light curve analysis (see below).

As discussed in Paper V, the amount of foreground reddening in the direction of the Clouds has been controvertial. We find the arguments for larger values more convincing. We have determined the foreground reddening for HV 982 in two ways. We have used the coarse-resolution (48 arcmin), H I-derived maps given by Schwering & Israel (1991). We have also used the LMC foreground reddening map presented by

**Table 7.** $E(B-V)$ reddening values for HV 982.

| Method | Resolution | $E(B-V)$ |
|---|---|---|
| **Foreground** | | |
| H I (Schwering & Israel 1991) | 48′ | 0.07 $\pm0.01$ |
| Stellar photometry (Oestreicher et al. 1995) | 10′ | 0.05 $\pm0.02$ |
| Adopted | | 0.06 $\pm0.02$ |
| **Total to star** | | |
| $(b-y)/c_1$[a] (Crawford 1978) | | 0.16 $\pm0.06$ |
| **To infinity** | | |
| H I (McGee & Milton 1966, Koornneef 1982) | 14.′5 | 0.11 $\pm0.035$ |

[a]Converted to $E(B-V)$ values using the relation $E(B-V) = E(b-y)/0.74$ (Crawford 1975).

Oestreicher, Gochermann & Schmidt-Kaler (1995), which is based on *UBV* photometry of foreground stars. This map has a spatial resolution of 10 arcmin.

The foreground reddenings from both resolutions are essentially concordant. They are presented in Table 7 along with the representative value adopted for the analysis that follows.

Table 7 also presents a value for the reddening to infinity, derived from the H I profile presented by McGee & Milton (1966) for the range of LMC velocities. This was integrated, converted to $E(B-V)$ values using the LMC $N(\mathrm{H\,I})/E(B-V)$ ratio given by Koornneef (1982) and added to the adopted foreground reddening. This total reddening is smaller than our value for the reddening to HV 982, but the uncertainties are such that there is no real inconsistency. It may be that the reddening to infinity is a more realistic indication of the reddening to HV 982, but we note that the McGee & Milton H I map has a resolution of 14.′5, which may hide small-scale reddening structure. Somewhat arbitrarily, we have adopted our photometrically-derived reddening for the temperature determination below. Comparison of the reddening to HV 982 with that to infinity possibly indicates that HV 982 lies towards the rear of the gas and dust in the LMC.

### 3.3 Light-curve analysis

The light curves of HV 982 indicate a well-detached, eccentric system. We have analysed them with the Wilson-Devinney (WD) code (Wilson 1994), which can treat a wide range of separations and several light curves simultaneously. We used a modified version of the WD code incorporating the atmosphere subroutine of the Calgary group (Milone, priv. comm.) which uses Kurucz model atmospheres rather than black bodies or the Carbon-Gingerich atmospheres of the standard version of the WD code. We adopted Kurucz atmospheres with abundance $[m/\mathrm{H}] = -0.3$.

We cannot determine the mass ratio $q = M_2/M_1$ for HV 982 without spectroscopic radial-velocity curves. However, the similar eclipse depths suggest stars of similar temperature and therefore, for coeval components, of similar mass. We therefore calculated models for $0.9 < q < 1.1$.

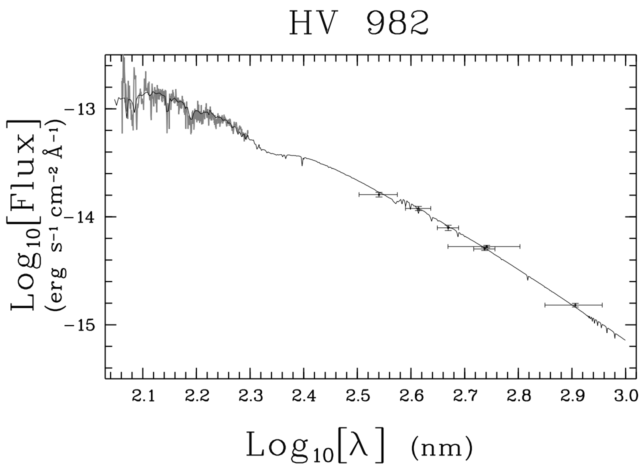


**Figure 6.** Reddened theoretical spectral fluxes for the adopted effective temperatures for HV 982 overplotted on the observed *IUE* uv spectrophotometry (∼5 per cent uncertainty) and calibrated $uvbyVI_{\rm C}$ fluxes (vertical error bars. The horizontal bars indicate the width of each bandpass.) The $uvbyVI_{\rm C}$ flux calibration is described in Paper V.

We used the Differential Corrections (DC) program of the WD code to optimize the values of eccentricity ($e$), longitude of periastron ($\omega$), phase offset, inclination ($i$), the effective temperature of the secondary component ($T_{\rm eff,2}$) for a given primary component effective temperature ($T_{\rm eff,1}$), the surface potentials of both components ($\Omega_1$ and $\Omega_2$), and the luminosity of the primary component ($L_1$). Limb-darkening coefficients were interpolated in tables calculated from the Kurucz models and the photometric system responses. Gravity-darkening exponents and bolometric albedos were set to theoretical values for radiative envelopes. Axial rotation rates were set to synchronization values at periastron. The results, in particular the ratio of the effective temperatures, luminosities and radii, are insensitive to the value of $q$.

However, in the multi-dimensional parameter space which descibes light-curve solutions, we have found several distinct local minima, all of which give satisfactory and similar fits to the light curves. We report four such case in Table 8. Iterations starting from parameter sets which differ significantly from any of these solution cases quickly converge to one or other of the four cases. For each of the four cases we performed more than 100 DC iterations for mass ratios of 0.9, 1.0 and 1.1 in order to investigate the stability of the solutions. The suggested corrections computed by DC do not converge to utterly negligible values but generally remain at a level comparable to their corresponding standard errors – the iterations are obviously bouncing around in the minima. The general level of the sum of the squares of the residuals for the four cases differ by less than 2%; this is comparable to, though slightly greater than, the fluctuation in the sum of the squares of the residuals from iteration to iteration. The radii and luminosity ratios however for the four cases are quite distinct. The ratio of the effective temperatures clearly separates into three cases – case 1 and case 2 being indistinguishable – however the overall range is less than 1%. All cases correspond to a cooler secondary component. It is also worth noting that the effective temperature

**Table 8.** Photometric elements for HV 982. The results are insensitive to the adopted mass ratio, $q$.

| | **Case 1** | **Case 2** | **Case 3** | **Case 4** |
|---|---|---|---|---|
| Eccentricity, $e$ | 0.155 | 0.155 | 0.161 | 0.158 |
| | ±0.001 | ±0.001 | ±0.002 | ±0.001 |
| Inclination, $i$ | 88°.7 | 89°.2 | 89°.4 | 88°.6 |
| | ±0°.1 | ±0°.2 | ±0°.3 | ±0°.1 |
| Longitude of | 223°.0 | 223°.0 | 225°.5 | 224°.0 |
| periastron, $\omega_0$ | ±0°.5 | ±0°.5 | ±0°.5 | ±0°.5 |
| Relative radii, $R_1/A$ | 0.201 | 0.197 | 0.215 | 0.209 |
| | ±0.002 | ±0.002 | ±0.002 | ±0.002 |
| $R_2/A$ | 0.212 | 0.215 | 0.196 | 0.204 |
| | ±0.002 | ±0.002 | ±0.002 | ±0.002 |
| Radii ratio | 1.05 | 1.10 | 0.97 | 0.91 |
| $R_2/R_1$ | ±0.02 | ±0.01 | ±0.01 | ±0.02 |
| Effective temperature | 0.972 | 0.972 | 0.982 | 0.976 |
| ratio, $T_{\rm eff,2}/T_{\rm eff,1}$ | ±0.001 | ±0.001 | ±0.002 | ±0.001 |
| Luminosity ratio | 1.07 | 1.12 | 0.80 | 0.91 |
| $(L_2/L_1)_V$ | ±0.03 | ±0.02 | ±0.02 | ±0.02 |

ratio varies by $\sim 0.5\%$ over the expected range of $T_{\rm eff,1}$ appropriate to early B stars (20 000 – 35 000 K). Table 8 lists the photometric elements corresponding to the four cases. The degeneracy of these four cases can only be broken with additional observational constraints. For example, the luminosity ratio of the two components could be used, provided it can be measured accurately enough from high resolution spectroscopy.

The results are of course heavily influenced by the large number of points in the $V$ light curve. To gauge systematic uncertainties in the derived geometric parameters, we in addition analysed the $V$ light curve with the EBOP code (Etzel 1981, 1993). The WD code uses gravitational equipotentials to delineate stellar surfaces, whereas EBOP, which is appropriate only for well-detached systems, uses spheroids. The WD and EBOP codes gave essentially identical results, never differing by more than twice the uncertainty reported in Table 8.

To obtain stellar temperatures, we have chosen to match observed and theoretical flux distributions because these are most directly related to effective temperatures. The adaptation of the WD code described in Paper V was used to generate theoretical flux distributions for a range of solution parameter sets corresponding to a range of values for the primary component effective temperature, $T_{\rm eff,1}$. The $\sim 1\%$ variation of the ratio of the effective temperatures amongst the four cases has no observable effect on the combined flux distribution of the two components to the accuracy of calculation for the theoretical flux distributions. Similarly the $\sim 20\%$ variation in the luminosity ratio has no observable effect on the temperature determination because of the nearly equal temperatures of the two components. The theoretical flux distributions were reddened by the appropriate Galactic and LMC extinction laws, as described in Paper V, and compared with the observed uv-visual flux distribution. Our finally adopted model (Figure 6) corresponds to effective temperatures $T_{\rm eff,1} = 28\,000 \pm 5\,000$ K and $T_{\rm eff,2} = 27\,200 \pm 5\,000$ K. The large uncertainties primarily derive from the uncertainty concerning the interstellar extinction laws (Paper V). For any adopted extinction law, the uncertainty in $T_{\rm eff,1}$ is ∼1 000 K, and for an adopted

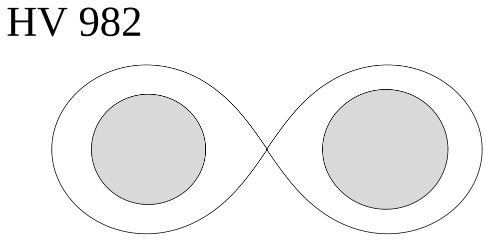


**Figure 7.** A schematic of the surface potentials and limiting Roche Lobes for HV 982. The example given above is for a case 2 solution with $q = 1.0$, at periastron.

$T_{\mathrm{eff},1}$, the uncertainty in $T_{\mathrm{eff},2}$ is $\sim$200 K. If the reddening to infinity is a more appropriate indication of the reddening of HV 982, the stellar effective temperatures will be approximately 23 000 and 22 200 K.

To check whether we have explored an adequate range of mass ratios, we used the Geneva evolutionary models (Schaerer et al. 1993). Although the Geneva models refer to single stars, they should be applicable because HV 982 is well detached. We searched for pairs of stars of the same age with effective temperatures of 28 000 K and 27 200 K. We also considered pairs of stars coresponding to the upper and lower limits implied by the uncertainties in our effective temperature determination. All resulting pairs of stars had mass ratios well within the range of 0.9 to 1.1 except for very massive systems where mass loss through stellar winds plays a critical role in the evolution. We can however ignore these possibilities on two counts. Firstly the *IUE* uv spectrum shows no features usually associated with strong stellar winds. Secondly, all such massive pairs would be far too luminous, in comparison with the luminosity implied by the observed uv-visual flux distribution, to be members of the LMC. We are confident therefore that our light curve investigation for mass ratios from 0.9 to 1.1 adequately samples parameter space.

The eccentricity of HV 982 shows it has not had time to circularize its orbit implying that its components are young and unevolved. At first glance, therefore, solutions such as cases 1 and 2 where the secondary is cooler but bigger than the primary might be thought unphysical for coeval stars, but we note that evolutionary models suggest that this can arise if both stars are near the TAMS: HV 2274 appears to be a case in point (Guinan et al. 1998).

Despite the absence of radial-velocity curves, we can estimate approximate physical characteristics for the components of HV 982 by adopting a distance and scaling the system to produce the observed flux at Earth. Adopting an LMC distance modulus of 18.35 (Schmidt-Kaler 1993), we find the stars in HV 982 have masses $M_1 \sim M_2 \sim 8\,\mathrm{M}_\odot$ and radii $R_1 \sim R_2 \sim 6.4 - 6.9\,\mathrm{R}_\odot$. The orbital semi-major axis $A \sim 32\,\mathrm{R}_\odot$. Figure 7 illustrates the extent to which HV 982 fills its Roche Lobes.

Several elements are still required before a definitive analysis can be made of HV 982. The appropriate interstellar extinction correction must be determined, which may involve determination of several parameters (e.g. Fitzpatrick & Massa 1990) via spectrophotometry from the uv to the near ir (Paper V). Radial-velocity curves and improved absolute photometry must also be obtained.

## 4 THE SPEED OF LIGHT AND THE MASS OF THE PHOTON

In the past, the speed of light, $c$, has been an important research topic in astronomy (see e.g. Tobin 1993). In more modern times, the constancy of $c$ with wavelength has been related to the possible mass of the photon, $m_\gamma$, as reviewed by Goldhaber & Nieto (1971). Over a small wavelength interval, such as the optical, it is easy to show that any change $\Delta v$ in the speed of light is related to the photon mass by $(\Delta v/c)/(\Delta\lambda/\lambda) = -(m_\gamma c\lambda/h)^2$. De Broglie (1940) in an obscure publication suggested using binary-star light curves to obtain an observational limit on $m_\gamma$, and at about the same time Hall (1939) compared minima of Algol at 550 nm and 866 nm, which he found simultaneous 'with an uncertainty of not more than three minutes,' corresponding to a velocity difference no more than 'about three parts in 55 million.' Hall was actually searching to explain wavelength-dependent discrepancies in the terrestrial measurement of $c$ recently made by Michelson, Pease & Pearson (1935); from his result one obtains $(\Delta v/c)/(\Delta\lambda/\lambda) < 1 \times 10^{-7}$ and $m_\gamma < 1 \times 10^{-39}$ kg.

Our data on HV 982 improves this limit significantly partly because of the better photometry and mostly because of the greater distance to the LMC. In Table 9 we report times of minima for our $u$, $V$ and $I_{\mathrm{C}}$ light curves, and their standard deviation. The primary eclipses are better determined. Any non-simultaneity cannot exceed $\sim$3 min. From this we deduce that any difference in $c$ over the range 350–800 nm is $(\Delta v/c)/(\Delta\lambda/\lambda) \lesssim 5 \times 10^{-11}$ and $m_\gamma < 3 \times 10^{-41}$ kg. While this result is of little research interest, we publish it because of its pedagogical value for physics teaching and historical associations. Observations of more sharply-defined astronomical events (i.e. pulses from the Crab pulsar) have already provided a limit one million times smaller (Feinberg 1969). The current best limit on the mass of the photon is $m_\gamma < 1 \times 10^{-51}$ kg and derives from satellite measurements of the magnetic fields of Earth and Jupiter (Davis, Goldhaber & Nieto 1975; Fischbach et al. 1994).

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This research has made use of the SIMBAD database operated at CDS, Strasbourg, France.

**Table 9.** Times of minima for the $u$, $V$ and $I_C$ light curves. The times have been determined by fitting gaussians to the fainter parts of the eclipses and have been standardized arbitrarily to the eclipses immediately following $T_0$. A correction is applied because the average epoch of the eclipse observations differs for the different filters, resulting in a shift due to apsidal motion.

| **Filter** | **Primary minimum** | **Secondary minimum** | **Mean epoch of obs.** | **Apsidal corrn. w.r.t. $V$** | **Corrected primary minimum** | **Corrected secondary minimum** |
|---|---|---|---|---|---|---|
| | HJD −2449355 | HJD −2449357 | HJD | day | HJD −2449355 | HJD −2449357 |
| $u$ | .3847 | .6692 | 2449227 | .0030 | .3877 | .6722 |
| | ±.0012 | ±.0019 | | | ±.0012 | ±.0019 |
| $V$ | .3869 | .6682 | 2449015 | 0 | .3869 | .6682 |
| | ±.0006 | ±.0007 | | | ±.0006 | ±.0007 |
| $I_C$ | .3845 | .6665 | 2449170 | .0022 | .3856 | .6687 |
| | ±.0011 | ±.0011 | | | ±.0011 | ±.0011 |

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